10/9

A DISSERTATION ON ELECTIVE ATTRACTIONS.

By TORBERN BERGMANN. K

LATE PROFESSOR OF CHEMISTRY AT UPSAL, AND
KNIGHT OF THE ROYAL ORDER OF VASA.

Tranſlated from the Latin by the TRANSLATOR
Of SPALLANZANI'S DISSERTATIONS.

LONDON:
PRINTED FOR J. MURRAY, No. 32. FLEET-STREET;
AND CHARLES ELLIOT, EDINBURGH.

M,DCC,LXXXV.

9

MUSEUM
BRITAN
NICUM

PREFACE.

THE uſefulneſs of publications, which, like the preſent Diſſertation, exhibit, from time to time, comprehenſive views of ſcientifical knowledge, has been ſufficiently pointed out by Lord BACON, whoſe dictates upon this ſubject, as upon others, have been amply confirmed by experience. The Tranſlator, therefore, at firſt thought, that every purpoſe of the Engliſh reader would be abundantly ſerved by a faithful tranſlation of this admirable manual of theoretical Chemiſtry. His duty plainly forbad him to alter or ſuppreſs any thing; and his reverence for the great author deterred him from the thought of making any addition. But ſome time has elapſed ſince the taſk of mere tranſlation was completed; in the mean time, chemical inveſtigation being continued with univerſal ardour, new facts were brought to light, and new theories propoſed, ſome of them in books not likely to fall into the hands of every reader. Hence it ſeemed almoſt a matter of neceſſity to add ſome annotations. The Tranſlator now wiſhes, for the convenience of the reader, that they had been ſubjoined to the pages to which they refer, though, for his own ſake, he is not ſorry that they are thrown back as far as poſſible. This accidental circumſtance of their ſituation has led him to be more diffuſe than he would otherwiſe have been. The notes could not, by their intruſion on the reader's eye, divert his attention from the author; and why ſhould any thing which was uſeful, and perhaps inacceſſible to many, be withheld, when it had any connection with the ſubject?

Two ſets of Tables are ſubjoined. It was thought that many readers would be diſſatisfied with the chemical Characters alone, eſpecially as the former edition of the Tables has been already publiſhed in words. To ſuppreſs the ſigns entirely, ſeemed improper; for they are ſo convenient, that every ſtudent of chemiſtry ought to make himſelf familiar with them. Beſides, as moſt Chemiſts will wiſh for a ſet to ſtand always open for inſpection, the two ſets will ſcarce be thought ſuperfluous by any.

Every man who delights in paying the reſpect that is due to genius, learning,

ing, and induſtry, will hear with pleaſure, that the life of our conſummate philoſopher has been promiſed us by his excellent friend, Mr Scheele. The following teſtimony of regret, on account of his premature death, appeared ſoon after that event; an event which thoſe who, by comparing what he did for chemiſtry with the ſhort time during which he applied to it, ſhall become ſenſible of what he would have accompliſhed in a long life, can alone adequately lament.

Pertriſtem adferre nuncium oportet,
Poſt exactos mortali vita annos XLIX,
Ereptum eſſe Patriæ,
Cultiori orbi, bonorumque omnium amplexibus,
VIRUM longè CELEBRATISSIMUM,
TORBERNUM BERGMANN.
CHEM. METALLURG. ET PHARMACEUT. IN
ACADEM. UPSALIENSI PROFESSOREM;
EQUITEM AURATUM REG. ORD. DE WASA;
ACAD. IMP. N. C.; REGIARUM ACADEMIARUM
ET SOCIETATUM PARIS. MEDICÆ PARIS.
MONTISPESS. DIVIONENS. UPSAL.
STOCKH. UTRIUSQUE LONDIN. GOETTING.
BEROLIN. TAURIN. GOTHOBURG. LUND.
SODALEM.

Id quod accidit d. viii. Julii anni 1784,
Dum ad acidulas Medvicenſes, in Oſtrogothia,
Adflictæ dudum valetudini quærebatur ſolatium,
Lugent per univerſam Suecogothiam
Optimarum ſcientiarum Patroni et Cultores;
Necdum inveniunt
Quem tanti viri deſiderio modum ponant.
Superſtitibus, autem, cognatis et amicis,
Hoc denique lacrimabile officium relictum eſt,
Ut, mœſtiſſimæ nomine viduæ,
Fautores in exteris gentibus et Conſortes ſtudiorum,
Quæ naturalis omnis ſcientiæ vir peritiſſimus
Excoluit,
De communi clade certiores faciant,
Proque ſuâ adeo agant parte,
Ut juſtiſſimi luctus æquè latè ſentiatur pietas,
Ac BERGMANNIORUM exiſtimatio meritorum
Jam diu inclaruit.

UPSALIÆ d. xvi. Julii
1784.

Fata tristem adferre nuncium cogimur,
Post exactos mortalis vitae annos XLIX,
Ereptum esse nobis,
Cultiori orbi, bonorumque omnium amplectendum
Virum longe carum [illegible],
TORBERNUM BERGMAN
CHEM. METALLURG. [illegible] in
ACADEM. UPSALIENSI PROFESSOREM;
EQUITEM AURATUM REG. ORD. DE WASA;
ACAD. IMP. N. C.; REGIARUM ACADEMIARUM
ET SOCIETATUM PARIS. [illegible] PARIS.
MONTISPESS. DIVIONENS. UPSAL.
STOCKH. UTRIUSQUE LONDIN. GOETTING.
BEROLIN. TAURIN. GOTHOBURG. LUND.
SODALEM.

Id quod accidit d. viii. Julii anni 1784.
Dum ad acidulas Medevienses in Ostrogothia,
Adflictae dudum valetudini [illegible] solatium,
Longe et per universam Sueogothiam
Optimarum scientiarum Patroni et Cultores
Necdum inveniunt
Quem tanti viri desiderio [illegible]:
Superstitibus, autem, cognatis, amicis,
Hoc denique lacrimabile officium relictum est.
Ut, moestissimae nomine viduae,
Fautores in exteris gentibus et Consortes studiorum
Quae naturalis omnis scientiae vir peritissimus
Excoluit:
De communi clade certiores faciant.
Propter sua adeo aequa parte,
Ut justissimi luctus [illegible] pietas,
Ac [illegible] meritorumque
Jam diu meruit.

Upsaliae d. xvi. Julii }
1784. }

CONTENTS.

Page

I. *There ſeems to be a difference between remote and contiguous attraction,* 1

II. *Single elective attractions,* - 6

III. *Whether the order of attractions be conſtant,* - - - 10

IV. *A difference in the degree of heat ſometimes produces a difference in elective attractions,* - - 14

V. *Apparent irregularities from a double attraction,* - - 18

VI. *Apparent exceptions from a ſucceſſive change of ſubſtances,* - 29

VII. *Apparent exceptions from ſolubility,* - - - 37

Page
VIII. *Exceptions from the combination of three ſubſtances,* - - 44
IX. *Exceptions from a determinate exceſs of one or other of the ingredients,* - - - 47
X. *How we are to determine the ſingle elective attractions,* - - 64
XI. *The neceſſity for a new table of attractions,* - - 69
XII. *Column firſt, the vitriolic acid,* 75
XIII. *Column ſecond, the phlogiſticated vitriolic acid,* - - 90
XIV. *Column third, nitrous acid,* 95
XV. *Column fourth, the phlogiſticated nitrous acid,* - - 99
XVI. *Column fifth, the muriatic acid,* 104
XVII. *Column ſixth, the dephlogiſticated marine acid,* - - 108
XVIII. *Column ſeventh, aqua regia,* 114

Page
XIX. *Column eighth, fluor acid,* 116
XX. *Column ninth, the arſenical acid,* 122
XXI. *Column tenth, acid of borax,* 127
XXII. *Column eleventh, acid of ſugar,* - - - 129
XXIII. *Column twelfth, acid of tartar,* - - - 134
XXIV. *Column thirteenth, acid of ſorrel,* - - - 140
XXV. *Column fourteenth, acid of lemon,* - - - 144
XXVI. *Column fifteenth, acid of benzoin,* - - 146
XXVII. *Column ſixteenth, acid of amber,* - - - 148
XXVIII. *Column ſeventeenth, acid of ſugar of milk,* - - 150
XXIX. *Column eighteenth, diſtilled vinegar,* - - 152

Page
XXX. *Column nineteenth, acid of milk,* - - 154
XXXI. *Column twentieth, acid of ants,* - - - 155
XXXII. *Column twenty-firſt, acid of fat,* - - 157
XXXIII. *Column twenty-ſecond, phoſphoric acid,* - - 158
XXXIV. *Column twenty-third,* acidum perlatum, - - 161
XXXV. *Column twenty-fourth, acid of Pruſſian blue,* - - - 164
XXXVI. *Column twenty-fifth, the aerial acid,* - - - 166
XXXVII. *Column twenty-ſixth, cauſtic vegetable alkali,* - 169
XXXVIII. *Column twenty-ſeventh, cauſtic mineral alkali,* - 173
XXXIX. *Column twenty-eighth, cauſtic volatile alkali,* - 175

XL.

Page
XL. *Column twenty-ninth, cauſtic ponderous earth,* - - 180
XLI. *Column thirtieth, lime,* - 185
XLII. *Column thirty-firſt, cauſtic magneſia,* - - - 187
XLIII. *Column thirty-ſecond, pure clay,* - - 188
XLIV. *Column thirty-third, ſiliceous earth,* - - - 189
XLV. *Column thirty-fourth, water,* 194
XLVI. *Column thirty-fifth, vital air,* 198
XLVII. *Column thirty-ſixth, phlogiſton,* - - - 219
XLVIII. *Column thirty-ſeventh, the matter of heat,* - - 229
XLIX. *Column thirty-eighth, ſulphur,* 279
L. *Column thirty-ninth, ſaline hepar,* - - - 282
LI. *Column fortieth, ſpirit of wine,* 284
LII. *Column forty-firſt, æther,* 285

Page
LIII. *Column forty-ſecond, eſſential oil,* 286
LIV. *Column forty-third, unctuous oil,* ib.
LV. *Column forty-fourth, gold,* 287
LVI. *Column forty-fifth, platina,* 290
LVII. *Column forty-ſixth, ſilver,* 292
LVIII. *Column forty-ſeventh, mercury,* 294
LIX. *Column forty-eighth, lead,* 297
LX. *Column forty-ninth, copper,* 298
LXI. *Column fiftieth, iron,* - 301
LXII. *Column fifty-firſt, tin,* 302
LXIII. *Column fifty-ſecond, biſmuth,* 303
LXIV. *Column fifty-third, nickle,* 305
LXV. *Column fifty-fourth, arſenic,* 309
LXVI. *Column fifty-fifth, cobalt,* 310
LXVII. *Column fifty-ſixth, zinc,* 313
LXVIII. *Column fifty-ſeventh, antimony,* - - - 314
LXIX. *Column fifty-eighth, manganeſe,* 315
LXX. *Column fifty-ninth, ſiderite,* 318

DIS-

DISSERTATION, &c.

Jamne vides igitur magni primordia rerum
Referre, in quali ſint ordine quæque locata,
Et commiſta quibus dent motus accipiantque.
LUCRETIUS.

THIS Diſſertation was firſt printed in 1775, in the third volume of the New Upſal Tranſactions. It was afterwards tranſlated both into German and French. The two annexed Tables, which exhibit the ſingle and double attractions, were again engraved in London, by the care of Dr Saunders, for the uſe of thoſe who attended the lectures which he read in conjunction with Dr Keir. The ſame year, Mr More, ſecretary to the Society for the Encouragement of Arts and Manufactures, publiſhed the table of elective attractions, on a large ſheet, ſubſtituting Engliſh words in the place of the ſigns.

ON

ELECTIVE ATTRACTIONS.

I.

There ſeems to be a Difference between Remote and Contiguous Attraction.

IT is found by experience, that all ſubſtances in nature, when left to themſelves, and placed at proper diſtances, have a mutual tendency to come into contact with one another. This tendency has been long diſtinguiſhed by the name of *attraction*. I do not purpoſe in this place to inquire into the cauſe of theſe phænomena; but, in order that we may conſider it as a determinate power, it will be uſeful to know the laws to which it is ſubject in its operations, though the mode of agency be as yet unknown.

It has been ſhewn by Newton, that the great bodies of the univerſe exert this power directly as their maſſes, and inverſely as the ſquares of their diſtances. But the tendency to union which is obſerved in all neighbouring bodies on the ſurface of the earth, and which may be called *contiguous attraction*, ſince it only affects ſmall particles, and ſcarce reaches beyond contact, whereas remote attraction extends to the great maſſes of matter in the immenſity of ſpace, ſeems to be regulated by very different laws; it ſeems, I ſay, for the whole difference may perhaps depend on circumſtances. Conſidering the vaſt diſtance, we may neglect the diameters, and look upon the heavenly bodies, in moſt caſes, as gravitating points. But contiguous bodies are to be regarded in a very different light; for the figure and ſituation, not of the whole only, but of the parts, produce a great variation in the effects of attraction. Hence quantities, which in diſtant attractions might be neglected, modify the law of contiguous attraction in a conſiderable degree; and, moreover, the great power of our globe on all occaſions influences and diſturbs it. This force may therefore produce wonderful variations in the effects, according to circumſtances. But as we are by no means able to aſcertain the figure and poſition of the particles, it remains that we determine the mutual relations of bodies with reſpect to attraction in each particular caſe, by experiments properly conducted, and in ſufficient number.

As contiguous attraction ſcarce extends beyond contact, it is obvious, that the former will be more intenſe in the ſame body, the more the latter is increaſed. Hence, in the following obſervations,

ſervations, many inſtances occur, which prove that a body has greater power in a liquid than in a ſolid ſtate, and ſtill greater when it is reſolved into vapour. See, in particular, what is ſaid of marine acid, with reſpect to phlogiſton, in the forty-ſeventh paragraph; and of the matter of heat, in the forty-eighth.

IN this diſſertation, I ſhall endeavour to determine the order of attractions according to their reſpective force; but a more accurate meaſure of each, which might be expreſſed in numbers, and which would throw great light on the whole of this doctrine, is as yet a deſideratum *.

SEVERAL

---

* Mr Morveau, I believe, firſt determined and expreſſed in numbers the coheſion of quickſilver to ſome of the metals. Mr Achard afterwards publiſhed a large table, in which the coheſive force of many bodies is inveſtigated both by calculation and experiment. Mr Kirwan very lately

Several ſpecies of contiguous attraction may be diſtinguiſhed. I ſhall here briefly mention the principal. When homogeneous bodies tend to union, an increaſe of maſs only takes place, the nature of the body remaining ſtill the ſame; and this effect is denominated *the attraction of aggregation.* But heterogeneous ſubſtances, when mixed together, and left to themſelves to form combinations, are influenced by difference of quality rather than of quantity. This we call *attraction of compoſition*; and when it is exerted in forming a mere union of two or more ſubſtances, it receives the name of *attraction of ſolution* or *fuſion,* according as it is effected either in the moiſt or the dry way. When it takes place between three reſpectively, to the excluſion of one, it is ſaid to be a *ſingle*

---

lately began to meaſure the attractions ,by the diminution of bulk that is produced by union; for he is of opinion, that the cauſe and quantity of contraction is to be ſought in the force of attraction.

elective attraction; when between two compounds, each conſiſting of only two proximate principles, which are exchanged in conſequence of mixture, it is intitled *double attraction.* I am particularly to conſider the two laſt ſpecies.

II.

Single Elective Attractions.

Suppose *A* to be a ſubſtance for which other heterogeneous ſubſtances *a*, *b*, *c*, &c. have an attraction; ſuppoſe, further, *A*, combined with *c* to ſaturation, (this union I ſhall call *Ac*), ſhould, upon the addition of *b*, tend to unite with it to the excluſion of *c*, *A* is then ſaid to attract *b* more ſtrongly than *c*, or to have a ſtronger elective attraction for it; laſtly, let the union of *Ab*, on the addition of *a*, be broken, let *b* be rejected, and *a* choſen in its place, it will follow, that *a* exceeds *b* in attractive power, and we ſhall have a ſeries, *a*, *b*, *c*, in reſpect of efficacy. What I here call attraction, others denominate affinity; I ſhall employ both terms promiſcuouſly in the ſequel, though the latter, being more metaphorical, would ſeem leſs proper in philoſophy.

GEOFFROY, in 1718, firſt exhibited at one view the ſeries of elective attractions, by arranging in a table the chemical ſigns, according to a certain order; but this admirable contrivance, while it is commended by ſome, is blamed by others; one party contending, that affinities are governed by fixed laws, and the other affirming, that they are vague, and to be aſcribed to circumſtances alone.

Now, ſince all chemical operations conſiſt either in analyſis or ſyntheſis, compoſition or decompoſition, and both the one and the other depend on attraction, it will certainly be of great importance to determine this diſpute. Let us not then lightly, and on account of one or two irregularities, perhaps ill underſtood, reject the whole doctrine, but let us rather proceed in our examination with caution and care. Should we even at laſt find that attractions depend on circumſtances, ſhall we therefore conclude, that it will be uſeleſs to know the ſeveral conditions that forward or impede or diſturb them? By no means, but rather that it will be of extenſive utility. There does not exiſt in all nature a ſingle phænomenon but what is ſo connected with certain conditions, that when they are abſent, the phænomenon ſhall either not appear, or be varied occaſionally. It is of conſequence to ſcience, that the changes and the combination of cauſes in every operation ſhould be accurately known, as far as a knowledge of them is attainable; and the utility of a ſtrict inquiry into attractions will, I hope, clearly appear from many inſtances in the following pages.

BUT if, on the contrary, a fixed order does really take place, will it not, when once aſcertained by experience, ſerve as a key to unlock the innermoſt ſanctuaries of nature, and to ſolve the moſt difficult problems, whether analytical or ſynthetical? I maintain, therefore, not only that the doctrine deſerves to be cultivated, but that the whole of chemiſtry reſts upon it, as upon a ſolid foundation, at leaſt if we wiſh to have the ſcience in a rational form, and that each circumſtance of its operations ſhould be clearly and juſtly explained. Let him who doubts of this conſider the following obſervations without prejudice, and bring them to the teſt of experiment.

III.

Whether the Order of Attractions be conſtant.

THIS queſtion can only be properly anſwered from what follows. But let us now ſlightly conſider whether a conſtant ſeries, ſuch as is mentioned in the laſt paragraph, is to be expected. Does *a* expel *b*, and *b a* reciprocally, according to circumſtances? Does *c* perchance expel *a*, while it always gives way to *b*? Let us conſult Experiment, the oracle of nature, with due care and patience, and we ſhall doubtleſs find the proper clue to guide us out of this labyrinth.

I AM far from approving of thoſe general rules which affirm, that earths and metals are in all caſes precipitated by alkalis, and metals by earths, for they are often fallacious. We have, however, many particular obſervations, which, when every thing is properly diſpoſed, never miſlead. We know, for inſtance, that volatile alkali is diſlodged by fixed alkali and pure calcareous earth; that quickſilver and ſilver are precipitated from nitrous and vitriolic acids on the addition of copper, which is again ſeparated by iron. Silver, quickſilver, and lead, which were called the white metals by the ancients, are ſeparated from the nitrous acid both by the vitriolic and marine. Do not theſe, and other facts long ſince known, ſhew, that there prevails a conſtant order among theſe ſeveral ſubſtances? Many other clear proofs occur in the explanation of the new table of attractions, which I ſhall reſerve for their proper places, (XII.—LXX.). The difficulties, when cloſely examined, diſappear; and none has yet, as far as I know, been pointed out which is really inconſiſtent with a continued ſeries. But ſhould there occur in this, as in other branches of natural philoſophy, a few phænomena, which appear to deviate from the ordinary track, they ſhould be conſidered as comets, of which the orbits cannot yet be determined, becauſe they have not been ſufficiently obſerved. Repeated obſervations, and proper experiments, will in time diſpel the darkneſs.

THAT the effect of three ſubſtances mixed together may appear at one view, I have contrived a way of repreſenting it by ſymbols. It will be proper to illuſtrate it by an example.

SCHEME 20. Pl. I. exhibits the decompoſition of calcareous hepar by the vitriolic acid. On the left ſide appears the hepar, indicated by the ſigns of its proximate principles united; but within the vertical bracket theſe principles are ſeen ſeparate, one above the other. On the right, oppoſite the calcareous earth, is placed the ſign of vitriolic acid; in the middle ſtands the ſign of water, intimating that the three ſurrounding bodies freely exerciſe their attractive powers in it. Now, as vitriolic acid attracts calcareous earth more forcibly than ſulphur does, it deſtroys the compoſition of the hepar; the extruded ſulphur being by itſelf inſoluble falls to the bottom, which is ſignified by the point of the lower horizontal half-bracket being turned downwards; and as the new compound, vitriolated calcareous earth (gypſum), alſo ſubſides, unleſs the quantity of water be very large, the point of the upper bracket is likewiſe turned downwards. The complete horizontal bracket indicates a new combination, but the half-bracket ſerves merely to ſhew by its point whether the ſubſtance from which it is drawn remains in the liquor, or falls to the bottom. The abſence of horizontal brackets indicates that the original compound remains entire. Such a combination only as continues unaltered can have a place on the right ſide, for if it be likewiſe decompoſed, a new caſe ariſes, which will be noticed hereafter, (V.). Thoſe operations which are performed in the dry way, are diſtinguiſhed by the character of fire, which is placed in the middle.

IV.

A Difference in the Degree of Heat ſometimes produces a Difference in Elective Attractions.

THE only external condition, which either weakens or totally inverts the affinities of bodies ſubjected to experiments, is the different intenſity of heat. But this cauſe can only operate in caſes where the ſame temperature renders ſome bodies remarkably volatile in compariſon of others.

Suppose *A* to be attracted by two other ſubſtances; and let the more powerful act at the ordinary temperature with the force *a*, the weaker with the force *b*: ſuppoſe, at the ſame time, the former to be the more volatile; let its effort to ariſe be expreſſed by *V*, and that of the other by *v*. When theſe three ſubſtances are mixed together, the ſtronger will attract *A* with a force $=a-b$; but ſhould the heat be gradually raiſed, this ſuperior force will be more and more diminiſhed; and as *V* will increaſe faſter than *v*, we ſhall at laſt have $a-b=V-v$. This ſtate of equilibrium will be immediately deſtroyed by the ſmalleſt addition of heat; and thus *b*, which was before the weaker, and incapable of producing any effect, will now prevail. If the other ſubſtance be entirely of a fixed nature, $v=0$, and the caſe will be ſimpler. Many inſtances of this nature will hereafter occur.

Hence, I think it in general obvious, that thoſe are the genuine attractions, which take place when bodies are left to themſelves: too high a degree of heat is an external cauſe, which forcibly weakens the real affinities more or leſs, nay, in ſome caſes, even totally alters them. Since, however, many operations cannot be carried on without the aid of heat, and the power therefore of this moſt ſubtile fluid is highly worthy of being obſerved, I think the table of elective attractions ought to be divided into two areas; of which the upper may exhibit the free attractions, that take place in the moiſt way, as the expreſſion is; and the lower, thoſe which are effected by the force of heat. This may eaſily be done, ſince we are as yet unacquainted with any other external condition which deſerves here to be taken into the account; if the internal conditions ever cauſe any deviation, it is either only apparent, or elſe a real change in the nature of the ſubſtances is produced. It cannot indeed be denied, that volatile bodies are actually changed by a combination with the matter of heat; but the change is of ſhort duration, as it totally diſappears on refrigeration, though not till after the deſired decompoſition has been effected.

It is hence evident, what opinion we are to form concerning the various arguments brought againſt the conſtancy of affinities, from the diſtillation, ſublimation, or fuſion of mixtures: ſuch ſometimes is the efficacy of heat, that ſtrong digeſtion, or even that degree of warmth which is produced by the combination of certain ſubſtances, is ſufficient to diſturb the uſual order.

V.

Apparent Irregularities from a double Attraction.

Notwithstanding the trite proverb, That no rule is without exception, I do not therefore think that rules are to be rejected; but the exceptions ſhould be properly inveſtigated, and the rules thus be reduced to their juſt amount. Thoſe, however, which are now to be conſidered, do not come under the denomination of exceptions; for four ſubſtances exert their action, a very different caſe, and more complicated, than where three only are concerned. Many inſtances uſually adduced in refutation of a regular ſeries of affinities belong to this head; and though it is ſaid that reciprocal decompoſition is evidently ſhewn by them, a cloſer examination will diſſipate the illuſion.

Geoffroy's table intimates, that fixed alkalis adhere to acids more ſtrongly than calcareous earth, and with great propriety, though ſome would repreſent this truth as an abſurdity. They drop a ſolution of chalk in nitrous acid into a ſolution of vitriolated tartar, upon which a precipitation of gypſum immediately takes place; a clear proof, as they think, of the ſuperior attraction of the calcareous earth. But it ſhould be obſerved, that not even quicklime, when added to a ſolution of vitriolated tartar, (Scheme 2.), produces any decompoſition; but, on the contrary, if vitriolic acid be dropped into the ſolution of calcareous earth, a precipitation of gypſum will follow, (Scheme 16.): Hence it is obvious to which the ſtronger elective attraction is to be attributed. When the chalk has been previouſly diſſolved in ſome mineral acid, four ſubſtances come into action; and now the earth, aided by the acid which is combined with it, effects what before it was not able to accompliſh. To render this more evident, let us conſider the 21ſt Scheme, in which, on the left hand, the neutral ſalt, known by the name of vitriolated tartar, is indicated by the ſign of vegetable fixed alkali placed near that of vitriol. I read it in this manner: Vitriolated vegetable alkali, (that is, ſaturated with the acid obtained from vitriol), a denomination by which the proximate principles are known; and theſe alſo appear under their proper ſigns within the adjacent vertical bracket. On the right, muriated lime (ſaturated with the marine acid) is likewiſe repreſented by ſymbols, as alſo its proximate principles within their proper bracket. Whilſt therefore vitriolated tartar and lime ſaturated with the acid of ſalt are mixed together in water, (which is expreſſed by the ſign of water in the middle of the Scheme), the ſame thing happens as if we were to mix certain portions of vegetable fixed alkali, vitriolic acid, marine acid, and pure lime in water: theſe four ſubſtances ſurround water in the figure, and are ſo to be placed, that the two acids ſhould never be in the ſame horizontal line.

We have the ſubſtances that were combined before mixture diſpoſed in a vertical poſition; and, in order to break the combination, there is neceſſarily required a greater ſum of attraction between thoſe which are horizontally, than thoſe which are vertically oppoſite to each other: and ſuch is the preſent caſe; for although the vitriolic acid attracts the fixed alkali more ſtrongly than it does the lime, yet, upon the addition of muriatic acid, which at once ſolicits the alkali, and diminiſhes its coheſion with the vitriolic acid, the attraction between the fixed alkali and the marine acid, together with the attraction between the vitriolic acid and the lime, make together a greater ſum than the attraction between the fixed alkali and the vitriolic acid, together with that between the muriatic acid and the lime.

The horizontal brackets include the new combinations: by the apex of the lower turned downwards, ſubſidence is denoted; but the apex of the upper pointing upwards, ſhews that the combination contiguous to it remains in the liquor, until a certain portion be carried off by evaporation. Thus then is the decompoſition in queſtion effected. That I may more quickly diſpatch the other inſtances, I ſhall once for all obſerve, that I always expreſs double ſalts (ſuch as conſiſt of two proximate principles) by the ſign of the baſe placed on the left, near the ſign of that ſalt from which the acid is ordinarily expelled, which acid is at preſent combined with the baſe: in the ſame way I deſign the others, conſiſting of two principles intimately united.

Magnesia, and ſeveral of the metals, reſemble lime in this reſpect. See Scheme 22. Table 1. contains ſixty-four ſchemes, which exhibit the events of 122 experiments; for No. 24. not only ſhews, that nitrated mercury is decompoſed by ſeret ſal ammoniac, but alſo that flaming nitre and vitriol of mercury will bear to be mixed without ſuffering any change; and, in general, if the ſubſtances repreſented on the right and left ſide make a mutual exchange of their principles, we may judge that thoſe which ſtand above and below undergo no ſeparation on mixture. In Schemes 21. and 23. it appears that vitriolated tartar and muriated lime change their principles, but not digeſtive ſalt and gypſum. Nos. 1.—20. exhibit the ſingle, 21.—40. the double free attractions. The following are brought about by the acceſſion of fire: 41.—47. and 55.—58. by diſtillation; 48.—50. and 59.—62. by ſublimation; and, laſtly, 51.—54. 63. and 64. by fuſion in a crucible. An explanation of the new characters is found in XI.

CHEMISTS, in determining the ſingle elective attractions, are often deceived by double attractions. The phoſphoric acid, as I ſhall hereafter ſhew, (XXXIII.), attracts lime more powerfully than fixed alkali; yet the contrary is aſſerted, ſince aerated alkali, by means of a double affinity, precipitates phoſphorated lime. Even cauſtic fixed alkali, which ſeems a ſtronger proof, cauſes a precipitation: nevertheleſs, if the ſuperior attraction is deduced from this alone, the concluſion will be erroneous; for the alkali only takes away the exceſs of acid which is requiſite for ſolution, and hence the phoſphorated lime falls to the bottom, (IX.). The difference between the action of alkalis and abſorbent earths, when ſaturated with aerial acid, and when deſtitute of it, has been explained in my eſſay on that acid, and may therefore be omitted here *. What is there ſaid of the volatile alkali, is expreſſed in Scheme 36. and clearly ſhews the reaſon why cauſtic volatile alkali ſeems to act more weakly than the mild, which otherwiſe would be abſurd. It may now, in general, be obſerved, that alkaline and earthy ſubſtances are to be conſidered as double, and by no means as ſimple ſalts, except in their cauſtic ſtate, and then I call them pure. See Schemes 1.—8. 32.—37. 51. 62. and 63.

The precipitation of metals, diſſolved in acids, by other metals, is never the effect of ſingle attraction; for during the

---

* Op. vol. i. p. 49.

the ſolution, a quantity of phlogiſton is extricated, as I have clearly, I hope, ſhewn elſewhere [*]. Since therefore metallic ſolutions are of ſuch a nature, that they cannot reſtore what they hold diſſolved to its metallic ſplendour without the acceſſion of a new portion of phlogiſton, it is ſelf-evident, as well as conformable to experiment, that this cannot be effected by the addition of calces. If therefore ochre be put into a ſolution of vitriol of copper, no copper will be precipitated; but iron added to the ſolution is ſoon obſerved to be covered with a cupreous pellicle; for it yields part of its phlogiſton, which is neceſſary to the reduction of the copper, and by this means becomes itſelf ſoluble without the emiſſion of any inflammable air, (Scheme 39.). Silver diſſolved in the nitrous acid is in like manner calcined; as appears from the red vapour, phlogiſtic ſmell, and various other evident ſigns, and therefore cannot be precipitated by the calx, though it may by regulus of copper, (Scheme 38.). The ſame obſervation is applicable to gold and the other metals; for in whatever way they be ſeparated, provided they can acquire no phlogiſton, they appear calcined, and really are ſo: the only difference conſiſts in this, that they are unequally dephlogiſticated, and that the noble metals can recover their loſs by fuſion alone in ignited veſſels, whereas the ignoble ones require an addition of phlogiſton. But more of this hereafter.

---

[*] Op. vol. ii. p. 354. vol. iii. p. 134.

In many other caſes, where a ſingle elective attraction is commonly thought to take place, it is really double, on account of the preſence of phlogiſton. Let us conſider an inſtance of this in the diſtillation of butter of antimony from a mixture of corroſive ſublimate and regulus of antimony. We may obſerve, in the firſt place, that neither mercury nor regulus of antimony are ſoluble in the marine acid, unleſs they are firſt deprived of a certain portion of their inflammable principle. From this conſideration, the proceſs is eaſily explicable from a double attraction: the calx of mercury in corroſive ſublimate is revivified by that phlogiſton which the regulus muſt loſe in order to become ſoluble in marine acid, (Scheme 58.). The baſis of corroſive ſublimate, indeed, as well as the calces of the noble metals, recovers its reguline ſtate in heat alone, by attracting what is wanting to this ſtate, through the ignited veſſels; but this operation requires a far ſtronger fire than the diſtillation of butter of antimony, in which the reduced mercury riſes without any very ſtrong heat. With white arſenic and corroſive ſublimate no decompoſition is effected, ſince the phlogiſton neceſſary for the reduction of the mercury is wanting; but this operation ſucceeds with orpiment, which abounds with phlogiſton.

VI.

Apparent Exceptions from a ſucceſſive Change of Subſtances.

If either of the ſubſtances employed ſhould change its properties, its attractions will, doubtleſs, be liable to alteration. This may be illuſtrated by many examples. It had been long known, that nitrous acid is capable of diſlodging the marine from an alkaline baſis; but Margraaf was the firſt who obſerved that the latter expels the former. This phænomenon, unleſs we are acquainted with the nature of marine acid, eludes all explanation; but now this is known, the problem is eaſily ſolved. The nitrous acid expels the marine, by means of a ſingle elective attraction,

traction, (Scheme 42.), but phlogiſton enters into the compoſition of the marine acid, and is attracted from it by other acids, eſpecially by the nitrous, (XVII.), which, even though ſaturated with vegetable alkali, ſtrongly attracts the inflammable principle; for nitre kept in a ſtate of ignition for an hour or two, remains perfectly neutral, whence it is plain, that all the acid remains, but it is become ſo much weakened, by being phlogiſticated, that it may be expelled by concentrated vinegar, (XXXVII.). Hence it follows, that part of the marine acid that is poured upon the nitre, yields its phlogiſton, in conſequence of the heat applied, to the nitrous acid, which in this ſtate is expelled by that part of the marine which is not yet decompoſed, (Scheme 55.). That this is the true explanation, appears from the nature of the thing, the neceſſary proportions, and the matter collected in the receiver, which is found to conſiſt of phlogiſticated nitrous acid and marine acid, both dephlogiſticated and in its ordinary ſtate.

On the ſame principle, white arſenic is capable, by diſtillation, of decompoſing thoſe neutral ſalts which contain the nitrous, but not thoſe which contain the marine acid. White arſenic is nothing but a ſort of ſulphur, conſiſting of the arſenical acid, and a certain portion of phlogiſton, (XX.). In this caſe, therefore, four ſubſtances come into action, (Scheme 56.); and as the nitrous acid ſtrongly attracts phlogiſton, and its connection with its baſis is much weakened by the acceſſion of that principle, the acid of arſenic is capable of expelling it: but the marine acid, already containing the inflammable principle, refuſes to combine with a larger portion of it, it therefore remains unchanged, and the arſenical acid has no power againſt the ſtronger, (Scheme 57.).

I HAVE long ſince obſerved, that the noble metals, though they reſiſt the force of fire ſo obſtinately, may be more or leſs calcined by ſolution in acids; and it will now be proper to add ſomething concerning iron, which, above all, ſeems liable to this change, eſpecially concerning its ſolution in the vitriolic acid. In the firſt place, we remark that a portion of phlogiſton flies off during ſolution in the inflammable air; next, if the ſaturated ſolution, which is of a green colour, be filtered, and kept in a full and cloſe phial, it will remain clear; whereas, if it be expoſed to the air in an open veſſel, it will gradually, but conſtantly, depoſit ochre, a phænomenon which ariſes from two cauſes. For vital and reſpirable air attracts phlogiſton ſo forcibly as inſenſibly to diminiſh that which is contained in the ſolution of iron. Such alſo is the nature of the vitriolic acid, that it will diſſolve ſo much the leſs iron, the more deſtitute the metal is of phlogiſton; whence it follows, that a quantity of acid ſufficient for the ſolution of iron but little dephlogiſticated, gradually becomes inſufficient in proportion as the phlogiſton is ſeparated, and therefore earth of iron muſt fall to the bottom, which, however, again diſappears on the addition of freſh acid. This decompoſition is much accelerated by heat, and eſpecially by boiling, and at laſt the green colour is changed to a dark red, and the whole ſolution aſſumes the nature of an ultimate ley, which is incapable of cryſtallization, as has been admirably ſhewn by Mr Monnet. Succeſſive boiling, however, and cooling, bring about the dephlogiſtication ſooner than continued boiling alone.

THIS ultimate lixivium, however, may be reduced by the addition of a little vegetable alkali, to white aſtringent cryſtals, like thoſe of alum, whence ſome have been led to believe, that the tranſmutation of vitriol into alum is fully proved; but this ſalt, when diſſolved, may be totally changed into Pruſſian blue, by means of phlogiſticated alkali, and, if common alkali be employed, affords nothing but ochre, and not a particle of alum, provided the vitriol be made by diſſolving iron; that indeed, which is extracted from pyrites, often contains alum, ſince clay frequently enters into the compoſition of pyrites.

WITH theſe truths in view, it is eaſy to anſwer, if any one ſhould think of proving the reality of reciprocal decompoſition by the caſe of alum, in which the acid ſeems to part with the earthy baſis upon the addition of iron filings, and take up the metallic, while, on the contrary, clay is diſſolved in the laſt lixivium of vitriol, and precipitates the ochre. In the firſt caſe, we have iron combined with its proper portion of phlogiſton, which, when it is put into a ſolution of alum, is taken up only by the exceſs of acid, which adheres more looſely than the ſaturating portion. And the abundant acid being taken away, the clay, being exactly ſaturated, falls down inſoluble. Theſe phænomena have therefore been hitherto ill underſtood, for at the preciſe point of ſaturation, clay is not precipitated by iron.

In like manner, copper yields the acids to iron, while it attracts them from crocus martis. Hence the decompoſition of vitriol of iron by copper, detected by Mr Margraaf, is eaſily explicable; it is by no means reciprocal, for copper precipitates iron only when it is dephlogiſticated beyond a certain limit.

In an open veſſel, the inflammable principle is eaſily ſeparated, eſpecially by means of heat; hence a ſolution of vitriol of iron muſt neceſſarily change in its nature almoſt every moment to a certain point, below which it is impoſſible to proceed in this way. It is the more ſurpriſing, that copper ſhould be ſo eaſily diſſolved in this experiment, ſince it is certain, that this metal is with great difficulty diſſolved in vitriolic acid, unleſs it be in ſome meaſure calcined beforehand. But in the preſent inſtance, the earth of the iron attracts the phlogiſton of the copper, which it ſoon loſes again on the application of heat. The ſolubility of the calx, as well as the regulus, of copper, in a boiling ſolution of martial vitriol, is a clear proof of this conjecture. Concentrated vitriolic acid indeed attracts copper, when aſſiſted by a ſufficient heat; but let it be remarked, that the vapours which then ariſe, are the phlogiſticated vitriolic acid, which ſhews, that a portion of the inflammable principle is carried off. Moreover, how the precipitations of metals from acids, by means of other metals, are to be properly underſtood, will be explained more at large hereafter.

VII.

Apparent Exceptions from Solubility.

It ſometimes happens that no decompoſition appears at firſt, though it really takes place. Fixed mineral alkali united with the acids to ſaturation, and diſſolved in water, remains in the limpid ſolution on addition of pure vegetable alkali, nor is any congrumation or precipitation to be obſerved. Hence chemiſts of great name have concluded, that the vegetable does not exceed the mineral alkali in attractive power; but let us ſuppoſe for a moment, that the mineral alkali is diſlodged, ſhould the ſolution become turbid? By no means, for the foſſil alkali is ſoluble of itſelf, and cannot therefore impair tranſparency. From this phænomenon alone, therefore, nothing certain is deducible; but let the ſolution be evaporated, and there will be found at laſt uncombined mineral alkali, ſeparately cryſtallized, and beſides, vitriolated tartar, if Glauber's ſalt, cubic nitre, if quadrangular nitre, and digeſtive ſalt, if ſea ſalt was ſubjected to the experiment, (Scheme 3.).

SOME metals precipitated from acids, by too much alkali, ſoon diſappear again in conſequence of ſolution. Platina and gold can ſcarce be precipitated in ſuch a manner that the ſolutions will not remain tinged. Zinc, copper, nickle, and cobalt, afford no precipitate when an exceſs of volatile alkali is uſed, unleſs they are contaminated by ſome heterogeneous ſubſtance.

THERE is yet another veil which often hides decompoſitions, as when the ſubſtance expelled from its combination is capable of diſſolving the new compound, or at leaſt does not hinder the water of ſolution from doing ſo. This happens not unfrequently when the acids of nitre and ſalt are expelled by thoſe of greater power. Thus the vitriolic takes magneſia from the marine, but in ſuch a way as totally to eſcape the notice of the ſenſes; for the extricated acid, ſharpening the water of the ſolution, immediately takes up the vitriolated magneſia, which is indeed otherwiſe of very eaſy ſolubility, and therefore no ſigns of it appear, until, by a ſpontaneous evaporation, the menſtruum is ſo much diminiſhed as to be incapable of diſſolving the whole. Several inſtances of this kind occur in the following paragraphs, and it is at the ſame time ſhewn how this impediment may be removed.

To this head we may alſo refer precipitations happening from a ſubtraction of the water of ſolution, upon the addition of a ſubſtance which, though it does not change the former combination, yet deprives it of its water, when there is not enough to diſſolve both; whence the compound ſuddenly concretes into ſmall cryſtals, nearly in the form of a precipitate. This happens when a proper quantity of concentrated vitriolic acid is poured into ſaturated ſolutions of vitriolated tartar, alum, corroſive ſublimate, and other ſalts, not eaſily ſoluble in water, though their proximate principles cannot be parted by vitriolic acid. Vitriol of mercury is really decompoſed by marine acid, which attracts the calx of the metal, and carries it down along with it to the bottom for want of water: but concentrated vitriolic acid alſo, when poured into a ſolution of corroſive ſublimate, throws down in its turn a white powder; whence ſome have immediately inferred that kind of decompoſition which is generally called reciprocal; but the latter precipitate is found, on examination, to be nothing elſe than true corroſive ſublimate deprived of the water of ſolution. Fixed vegetable alkali, particularly when dry and cauſtic, produces like effects in the ſame circumſtances; I mean, when the baſis attracts the acid with equal or greater force than the alkali employed.

THESE precipitations are ſeldom complete; for ſomething generally remains diſſolved in the liquor.

FINALLY, let me notice thoſe anomalous phænomena which depend on apparent ſolubility. Liquor of flints, as is well known, contains ſiliceous earth, diſſolved in water by means of fixed alkali. Upon dropping in an acid, the ſiliceous earth ought to be precipitated, as really happens, unleſs the liquor be diluted in twenty-four times its weight of water, or more; in this caſe, no cloudineſs is perceptible, though even more acid be affuſed than is neceſſary for ſaturating the alkali. We have here an appearance of ſolution; but the truth is, that the ſiliceous particles are ſo diſperſed in the abundance of water, that they cannot ſubſide on account of the great proportion of their ſurface to their weight. As I have elſewhere explained this at greater length *, I need only give a ſhort view of the matter here. I ſhall only add, that the earth cannot be diſſolved by the neutral ſalt that is formed; for the ſiliceous particles fall down on ebullition, (which increaſes ſolubility upon other occaſions),

---

* Op. vol. ii. p. 36.

ſions), in conſequence of the diminiſhed denſity of the liquor by heat. Should any one object, that, for the ſame reaſon, other earths ought alſo to be ſuſpended, he will readily find, on more mature conſideration, that, 1. no other of the primitive earths is ſoluble in alkali, except the argillaceous, which is alſo ſoluble in acids, ſo that there can be no exceſs either of the one or the other without ſolution. 2. Calcareous earth is not precipitated from acid menſtruums in a viſible form by cauſtic fixed alkali well diluted, and gradually dropped in, till paper dyed with brazil wood is changed to a blue, provided the ſolution be firſt diluted with fifty times its bulk of diſtilled water. The liquor remains clear for a time, but by degrees acquires a film on the ſurface. The ſolution employed ought to contain more calcareous earth than an equal quantity of the ſtrongeſt lime-water, otherwiſe it might be ſaid, that the calcareous earth is really diſſolved in the clear alkaliſed ſolution, and not ſuſpended. If a ſingle drop of aerated alkali be dropped into the clear ſolution without agitation, white clouds immediately come into view; but if an equal drop be added, while the whole maſs is ſhaken, no cloudineſs enſues, for the motion prevents the coaleſcence of the ſeparated molecules. Here then we have calcareous earth certainly ſuſpended, and all ground of contradiction, I hope, removed.

VIII.

Exceptions from the Combination of three Subſtances.

THERE are ſome ſubſtances of ſuch a nature, that three are capable of uniting without the excluſion of any one. The combination of two attracts a determinate quantity of a third, and ſometimes of more, with ſo much force, that they become very cloſely connected, and are ſcarce to be ſeparated by any art. This inconvenience more eſpecially attends the dry way; for the earths mixed either with one another, or with ſalts, melt together without excluſion, which is alſo true of moſt of the metals. *A* is not indeed attracted by *a* and *b* with equal force, but rather *A a* unites with *b*, or *A b* with *a*, which yet is no reaſon why *a* ſhould not exceed *b* in attraction, though the particular nature of the combinations prevents excluſion. Volatile alkali, marine acid, and the calx of quickſilver, volatile alkali, vitriolic acid, and magneſia; iron, vitriolic acid, and magneſia, not to mention other inſtances, adhere ſo cloſely in determinate proportions, that they cannot be ſeparated by cryſtallization, and not eaſily in any other way.

THIS alſo holds with reſpect to four ingredients, as borax with tartar, vitriolated magneſia with common ſalt, gypſum with common ſalt, and many others. To this head alſo belongs liver of ſulphur formed in the dry way by vitriolated tartar and powder of charcoal, as in this caſe the phlogiſton is firſt conceived to ſeparate the acid, and generate ſulphur, which then is diſſolved in the alkali, and yields hepar; it may ſeem that the newly formed particles of ſulphur can ſcarce perſiſt in ſo great an heat, without either being ſublimed or conſumed, but the new compound is formed almoſt in the ſame moment.

FROM this property of certain ſubſtances, peculiar phænomena often ariſe. Should any one attempt to precipitate vitriolated magneſia, or muriated magneſia, by volatile alkali, he will indeed obtain ſome precipitate, but a new triple combination, a ſalt of a peculiar nature, will be formed. If ſaturated ſolutions of nitrated lime and nitrated magneſia be mixed, an unexpected precipitate appears, conſiſting of a triple ſalt, compounded of both earths and the common acid, more difficult of ſolution than either of the ingredients, and on this account falling to the bottom. The new ſalt is taken up by a larger quantity of water. I muſt overpaſs many phænomena of this nature.

IX.

Exceptions from a determinate Exceſs of one or other of the Ingredients.

Some chemiſts, I know, contend, that it is idle to ſuppoſe that a determinate exceſs of acid can be received by neutral or middle ſalts. Many inſtances, however, which I ſhall now mention, clearly prove the preſence of ſuch exceſs,

ceſs, which, agreeably to the nature of the thing, adheres more looſely than the ſaturating portion. Let perfectly neutral tartarized tartar be diſſolved to ſaturation in diſtilled water; then let ſome genuine acid of tartar (XXIII.) be dropped in, and a white ſpongy ſubſtance will ſeparate and fall to the bottom, which, when collected and examined, proves to be real tartar. What is the cauſe of this ſingular alteration? We ſhall eaſily aſcertain it by conſidering the nature of the ſubſtances. Tartar is nothing but vegetable alkali with a greater portion of its own acid than is neceſſary to ſaturation. He who is acquainted with the taſte of tartar, its efferveſcence with alkalis, the red colour it gives to blue vegetable juices, &c. can entertain no doubt concerning the exceſs of acid; nay, even till our own times, tartar was conſidered as an acid. Take away the abundant acid by the addition of vegetable alkali, and you will have tartarized tartar, which the French call vegetable ſalt, *ſel vegetal.* Purified tartar is therefore nothing but tartarized tartar with a determinate exceſs of acid; and when this is added to tartarized tartar, it is immediately generated, and, for want of a ſufficient quantity of water to diſſolve it, falls in great meaſure to the bottom. Tartar, therefore, and tartarized tartar, differ not in the nature, but the proportion of their ingredients; neverthleſs this cauſe produces a wonderful difference in taſte and other properties, and eſpecially in ſolubility. For tartarized tartar attracts water ſo forcibly, that it commonly deliqueſces in moiſt air: on the other hand, one part of tartar requires 150 parts for its ſolution in a middle temperature; which is ſo much the more ſurpriſing, as we are certain, that the ſuperfluous acid, by itſelf, as well as tartarized vegetable alkali, readily unites with water. The exceſs, which occaſions the difference, can neither be removed by cryſtallization, a moiſtened filter, or, in ſhort, by any other way but ſaturation.

We have therefore a manifeſt example, from which we may conclude, that vegetable alkali, though ſaturated, does not reject, but, on the contrary, eaſily admits an exceſs of the acid of tartar. There is here too a clear inſtance of attraction between a neutral ſalt and an acid of the ſame ſpecies as that which enters into the compound. If any other acid be poured into tartarized tartar, tartar is alſo ſeparated; a phænomenon uſually explained by ſaying, that the acid employed expels the tartar by ſuperior attractive force. But tartar is not a pure acid, as was long ſuppoſed. Why then is the alkali united to it expelled at the ſame time? If the precipitation ariſe from ſuperior attraction, why ſhould acid of tartar effect it? Why ſhould vinegar, an acid really weaker, (XXXVII.)? That we may diſtinctly perceive what happens in this operation, let the tartarized tartar be imagined to be divided into two parts, ſo that one part *b* ſhall contain as much acid as is neceſſary for the other *a* to become tartar. Now let the foreign acid be added, ſo as to ſaturate the alkaline baſis of the part *b*, the acid of tartar before combined with it will flow back to the portion *a*, which already tends to it with ſo much force, that it immediately ſeizes it, and is converted into tartar, provided any thing capable of weakening the coheſion of the principles in *b* but in a ſmall degree be added.

Salt of Seignette ſhews the ſame phænomena. If a ſolution of volatile alkali be gradually ſaturated with acid of tartar, another ſpecies of ſoluble tartar will be formed, which is immediately clouded by exceſs of acid, and a new tartar is exhibited, very difficultly ſoluble, but, on account of the looſer connection of the principles, more acid than the common ſort.

But it is not only tartar which eſſentially requires an exceſs of acid. We have long been acquainted with ſeveral ſalts of this kind. Salt of ſorrel conſiſts of vegetable alkali and a peculiar acid in exceſs, (XXIV.). So alſo acid of arſenic, preciſely ſaturated with vegetable alkali, cannot be cryſtallized; but if there be a proper exceſs of acid, we eaſily obtain beautiful cryſtals, (XX.). Hence it appears why it has hitherto been impoſſible to prepare Mr Macquer's arſenical ſalt in a crucible; for the neceſſary exceſs has always been expelled by the force of fire.

Duhamel and Grosse have obſerved, that ſoluble tartar may be prepared

red from the abſorbent earths, without however underſtanding the real nature of the operation. Now, as upon the addition of alkali, the exceſs of acid is ſaturated, and the whole maſs becomes ſoluble, ſo chalk, by abſorbing this exceſs, immediately generates a ſalt of difficult ſolubility, which of courſe is precipitated, (XXIII.); but when the exceſs of acid is ſeparated from the tartar, nothing but tartarized tartar, which is very ſoluble, remains.

In 1760, Mr Baumé publiſhed an experiment highly deſerving of attention, from which he thinks it evident, that vitriolated tartar may be totally decompoſed by nitrous acid in the humid way. By this inſtance, in the opinion of ſome modern writers, reciprocal affinities are proved beyond all doubt; but a cloſer examination will diſſipate the whole ambiguity. It is therefore to be obſerved, 1*ſt*, That vitriolated tartar,

tar, diſſolved in water, may be cryſtallized by evaporation, after the addition of a quantity of concentrated vitriolic acid, equal to one third of the ſalt. The cryſtals, with the acceſſion of one third of their weight, remain dry, notwithſtanding they are acid. More acid affords a deliqueſcent ſalt. The exceſs of acid cannot eaſily be driven off by diſtillation in a retort; this end may be more readily obtained by fuſion in a crucible. Repeated cryſtallizations are of no avail. Waſhing with highly rectified ſpirit of wine is the beſt method of edulcoration. *2dly*, We know, that vitriolic acid in proper quantity completely decompoſes nitre even in the moiſt way, whence its ſuperior power of attraction is evident. There is here, therefore, no occaſion for a diſtinction between the dry and the moiſt way. *3dly*, A third part only, or a very little more, of vitriolated tartar, diſſolved in ſtrong and hot nitrous acid, is decompoſed, whatever quantity of the acid be employed. *4thly*, There is no occaſion to apply heat, or uſe concentrated nitrous acid; for to a portion ſo much diluted that it emitted no fumes, I added a large quantity of powdered vitriolated tartar, ſet it in a cool place for thirty-ſix hours, and then poured off the liquor; from which highly rectified ſpirit of wine precipitated a white powder, which being collected and dried, proved to be real nitre; and it deſerves to be remarked, that the vitriolated tartar which was not decompoſed, was ſo ſoluble by the aid of the ſuperfluous acid, as to be ſcarce ſeparable by ſpirit of wine. *5thly*, Vitriolated tartar, with a proper exceſs of acid, as that in obſerv. 1. is not at all changed by the moſt concentrated nitrous acid. It is ſcarce ſufficient to moiſten the vitriolated tartar in powder with vitriolic acid; they muſt be diſſolved together in hot water. *6thly*, Not only the nitrous, but the marine, the tartareous, and perhaps many other acids, in like manner decompoſe vitriolated tartar. Glauber's ſalt, or vitriolated mineral alkali, is alſo totally ſoluble in marine acid; but about a third part only is decompoſed, as Mr Kirwan has obſerved. *7thly*, Two thirds of the vitriolated tartar, which remain unchanged, form cryſtals with the exceſs of vitriolic acid, of the ſame nature with thoſe which are procured in the way mentioned in the firſt of theſe conſiderations.

If we weigh theſe obſervations, it will plainly appear that the ſame thing happens in the preſent caſe, as in that of tartarized tartar. Suppoſe *b* to be ſuch a portion of the vitriolated tartar, as to contain exactly that exceſs, which the other portion *a* can receive. Nitrous acid of itſelf cannot deprive the vitriolic of its baſis; but *a* attracting it at the ſame time, ſo far diminiſhes the reſiſtance, that the nitrous is able to ſeize the alkaline baſis of *b*, but its power is confined to certain limits. Suppoſe the vitriolated tartar to be divided into two parts, one of which affords its baſis to the nitrous acid, and the other is not decompoſed. We have here three powers: let that by which the part of the vitriolated tartar remaining entire attracts a determinate exceſs of acid, be called *A*; *B*, that by which the part to be decompoſed endeavours to retain its baſis; and, laſtly, *C* the force of attraction of the nitrous acid to the ſame baſis, it is obvious that no decompoſition can be effected, if $A + C < B$, or if $A + C = B$; but if $A + C > B$, it immediately takes place.

WHAT has been ſaid concerning the ſolution of vitriolated tartar in nitrous acid, is in like manner applicable to Glauber's ſalt, ſecret ſal ammoniac, and perhaps many others, ſo that thoſe decompoſitions cannot be deduced from the preſence of phlogiſton, in the alkaline ſalt. Concentrated ſolutions of nitre and digeſtive ſalt yield, upon the addition of acid of tartar, a real tartar, for the reaſons above aſſigned; but quadrangular nitre and ſea ſalt, of which the baſis, mineral alkali, has a far different attraction for acid of tartar, afford no precipitation in experiments of this kind.

Several apparent exceptions originate from the removal or diminution of exceſs of acid; for various ſubſtances produce, with certain menſtruums, ſalts ſo difficult of ſolution, that they cannot be held ſuſpended without ſome exceſs. Thus lime is ſoluble in abundant acid of arſenic; but cauſtic volatile alkali, magneſia, lime itſelf, and, in ſhort, whatever is capable of abſorbing the abundant acid, immediately produces precipitation. If any one ſhould hence conclude that lime is expelled by cauſtic volatile alkali and magneſia, he is certainly deceived, and ought likewiſe to maintain, that this is done by the lime itſelf. The precipitate, when examined, does not exhibit lime alone, but lime ſaturated with arſenical acid, which ſufficiently explains the nature of the operation. The ſame phænomena occur with lime diſſolved in phoſphoric acid, and with many other ſubſtances of difficult ſolubility.

Almoſt all the metallic ſalts redden tincture of turnſole; and the exceſs can ſcarce be removed without deſtroying the ſalt.

BUT it is not the acids alone which ſometimes exceed the limits of ſaturation; this is likewiſe true of the ſaline, earthy and metallic baſis. Borax, however well purified, exhibits clear marks of abundant alkali, and ſtill requires about an equal weight of ſedative ſalt, to be completely ſaturated. Why the arſenical acid, though perfectly ſaturated with vegetable alkali, ſhould yet expel the acid of nitre in diſtillation, I have already ſhewn, (VI.) ; but I may here add that the acid of arſenic likewiſe attracts an exceſs of alkali, when circumſtances allow, and this force undoubtedly promotes the ſeparation. On the ſame principles, the acid of arſenic, exactly ſaturated with vegetable alkali, decompoſes liver of ſulphur and ſoap, as Mr Scheele has diſcovered. In alum there is an exceſs of acid, ſo that it reddens turnſole, and is capable of receiving a ſtill greater exceſs, and reciprocally of being combined with its own baſis beyond the bounds of ſaturation. The calx of lead may alſo be combined in exceſs with plumbum corneum, and ſaccharum ſaturni. Turbith mineral and powder of algaroth have an exceſs of their baſis, and, after the moſt careful waſhing, yield, on diſtillation, a portion of acid. I omit other inſtances; and from thoſe which have been adduced, I think it evident that the doctrine concerning a determinate exceſs of one or other of the ingredients, is not only not abſurd, but that it actually takes place on many occaſions. The exceſs commonly adheres leſs firmly than the portion requiſite for ſaturation, and therefore in many inſtances may be eaſily removed, but it is not on this account the leſs real. There is in theſe caſes, as I have before remarked, an attraction between the ſaturated ſalt, and a determinate exceſs of the acid or the baſis. Perhaps ſuch an attraction takes place in all compound ſalts, and ſometimes the power which attracts the acid, and at others, that which attracts the baſis, may prevail, though we are as yet acquainted with only a few inſtances. It is alſo probable that the ſaline particles, when diſſolved, can admit of a greater exceſs than when in a concrete ſtate; at leaſt, ſuch is their relation to the matter of heat, a ſubſtance far more ſubtile, for when they coaleſce after they have been ſeparated, they part with a certain portion which they attract when diſſolved. A new field opens here before us, as yet uncultivated, and indeed ſufficiently difficult, ſince the attraction of compounds is weaker and ſometimes ſcarce perceptible; ſometimes, however, remarkable phænomena are to be derived from them alone. Let mercury, for inſtance, be digeſted in an equal weight of nitrous acid, with ſuch a degree of heat as will prevent cryſtallization. At firſt the metal is taken up with efferveſcence in the common manner, but at length the generation of bubbles ceaſes, nor does any nitrous air ariſe, though in the mean time moſt of the mercury inſenſibly diſappears. In this experiment, ordinary nitrated mercury, with a calcined baſis, is formed, and this is afterwards ſaturated with mercury, that retains its phlogiſton. If a ſolution of ſea ſalt be added to a ſolution of this ſalt, a white powder is precipitated, which is real mercurius dulcis, and which in the laſt Swediſh Pharmacopœia is directed to be prepared in this way *. When the mixture is made, the marine acid attracts the calcined mercury, and forms corroſive ſublimate, which immediately ſeizing the complete mercury, becomes perfectly mild; nor does any thing elſe happen when calomel is prepared in the dry way.

X.

---

* Scheele in the Stockh. Tranſactions, 1778.

X.

How we are to determine the ſingle Elective Attractions.

After this view of the difficulties which may occur, let us haſten to our ſubject. Suppoſe *a*, *b*, *c*, *d*, &c. to be different ſubſtances, of which the attractive forces for *A* are to be aſcertained.

A.] Let *Ad*, (i. e. *A* ſaturated with *d*,) be diſſolved in diſtilled water, and then add a ſmall quantity of *c*, which may either be ſoluble in water by itſelf or not. Firſt let it be ſoluble; then a concentrated ſolution ought to be employed, which, when dropped into a ſolution of *Ad*, ſometimes immediately affords a precipitate, which, being collected and waſhed, either proves to be a new combination, *Ac*, with peculiar properties, or *d* is extruded, or ſometimes both. It now remains to be examined, whether the whole of *d* can be diſlodged by a ſufficient quantity of *c* from its former union. It ſhould be carefully noted in general, that there is occaſion for twice, thrice, nay ſometimes ſix times the quantity of the decomponent *c*, than is neceſſary for ſaturating *A* when uncombined. If *c* effect no ſeparation, not even in ſeveral hours, let the liquor ſtand to cryſtallize, or at leaſt become dry by a ſpontaneous evaporation; high degrees of heat muſt be avoided, leſt they diſturb the affinities, (IV.). Here the knowledge of the form, taſte, ſolubility, tendency to effloreſce, and other properties, even thoſe which, in other reſpects, appear of no conſequence, of the ſubſtances, is of great uſe in enabling us to judge ſafely and readily, whether any, and what decompoſition has taken place. Sometimes the diſengaged ſubſtance, whether that which was added or expelled, gives the operator much trouble, by concealing the genuine properties of the other, and therefore, if poſſible, ſhould be removed, according to circumſtances, either by water or ſpirit of wine.

Next, ſuppoſe *c* to be inſoluble, as, for inſtance, a metal, let a bright and clean plate of it be put into the ſolution of *A d*, and let it be obſerved, whether any thing is precipitated. By putting ſeveral laminæ in ſucceſſion, we find at laſt whether a part only of *d*, or the whole, is ſeparated. Sometimes no decompoſition is effected, though the ſurface of the metal ſhould have been lately filed, unleſs there be a ſmall exceſs of acid; and as far as I have hitherto been able to collect, it is not always of conſequence that the ſuperfluous acid ſhould be of the ſame nature as that which *A d* contains or not.

If only one of the compounds *Ad* and *Ac* be ſoluble in highly rectified ſpirit of wine, there is ſcarce any need of evaporation; for if the mixture be made, and left a few hours at reſt, and then ſpirit of wine be added, that which cannot be diſſolved in it is ſeparated.

The ſmell alſo often indicates what is taking place. Thus, vinegar, acid of ants, of ſalt, nitre, volatile alkali, are eaſily diſtinguiſhed when ſet free. The taſte likewiſe often informs an experienced tongue.

b.] Let *Ad* then be treated with *b* and *a*, &c. ſeparately in the ſame manner.

c.] In like manner, let *Ac*, *Ab*, *Aa*, be examined in their order.

By ſuch an examination properly conducted, the order of attractions is diſcovered. This taſk, however, exerciſes all the patience, and diligence, and accuracy, and knowledge, and experience of the chemiſt. Let us ſuppoſe only a ſeries of five terms, *a*, *b*, *c*, *d*, and *e*, to be examined with reſpect to *A*, twenty different experiments are requiſite, of which each involves ſeveral others: a ſeries of ten terms requires ninety experiments, and, in general, if *a* be the number of the ſeries, $n.\overline{n-1}$ will be the number of experiments.

d.] In like manner, each compound with *a*, *c*, *b*, ſhould be examined in the dry way; but it muſt be in a crucible, or, if poſſible, in a retort heated to incandeſcence, that the volatile part may be collected at the ſame time.

Such, in general, is the method which I have followed; the continuance of this labour will perhaps diſcover various ſhorter paths, which will at leaſt be convenient in certain caſes. But we ſhould be cautious in guarding againſt fallacies ariſing from the apparent exceptions above deſcribed.

XI.

The neceſſity for a new Table of Attractions.

THE tables which we have at preſent contain only a few ſubſtances, and each of theſe compared only with a few others. This is no reproach to the authors of them, for the taſk is laborious and long. Although, therefore, I have been employed upon it with all the diligence I could exert, and as much as my many other engagements would permit, yet I am very far from venturing to aſſert, that that which I offer is perfect, ſince I know with certainty, that the ſlight ſketch now propoſed will require above 30,000 exact experiments, before it can be brought to any degree of perfection. But when I reflected on the ſhortneſs of life, and the inſtability of health, I reſolved to publiſh my obſervations, however defective, leſt they ſhould periſh with my papers, and I ſhall relate them as briefly as poſſible. In itſelf it is of ſmall conſequence by whom ſcience is enriched; whether the truths belonging to it are diſcovered by me or by another. Meanwhile, if God ſhall grant me life, health, and the neceſſary leiſure, I will perſevere in the taſk which I have begun. I ſhall now explain the end I had in view, and my plan; ſhould they be approved by the maſters of the ſcience, I hope that many will lend me their aſſiſtance, for it is eaſier to accompliſh one or two columns, than to bring all to perfection: I exhibit a great number of the more ſimple ſubſtances which occur in chemiſtry. Many of theſe are not only compounded, but are eaſily reſolved into their proximate principles, ſuch as hepar, ſulphur, the imperfect metals, *&c.*; but they do not come into view here, but inaſmuch as they effect compoſition and decompoſition in their entire ſtate; but when their proximate conſtituent parts are ſeparated, double attractions take place, which are not conſidered in this table.

Moreover, I have inſerted many lately diſcovered, of uncertain origin and compoſition, ſuch as the acids of fluor, arſenic, tartar, ſugar, and ſorrel; of earths, magneſia and terra ponderoſa; of metals, platina, nickle, manganeſe, and ſiderite, of which more in the place belonging to each. In the obſcurity of their origin, theſe ſubſtances agree with others that have been the longeſt known. Should they be derived from others, they ought not, on this account, to be excluded, for they are now different, have conſtant properties, exerciſe their attractive powers without decompoſition, and can at pleaſure be obtained perfectly alike. It is therefore proper to inquire into their powers. Every ſubſtance that we employ is probably compounded, and although we are at preſent ignorant of its principles, they may hereafter be detected.

The upper ſtratum of the table, if I may ſo call it, contains fifty-nine rectangles horizontally placed, which exhibit fifty-nine different ſubſtances, denoted by ſigns formerly in uſe, or by new ones, which I ſhall now therefore enumerate in the order of the adjacent numbers, for there is ſcarce any one in the following which does not appear in the firſt: 1. Is vitriolic acid; 2. Phlogiſticated vitriolic acid; 3. Nitrous acid; 4. Phlogiſticated nitrous acid; 5. Muriatic acid; 6. Dephlogiſticated muriatic acid; 7. Aqua regia; 8. Fluor acid; 9. Arſenical acid; 10. Acid of borax; 11. Acid of ſugar; 12. Acid of tartar; 13. Acid of ſorrel; 14. Acid of lemon; 15. Acid of benzoin; 16. Acid of amber; 17. Acid of ſugar of milk; 18. Diſtilled vinegar; 19. Acid of milk; 20. Acid of ants; 21. Acid of fat; 22. Acid of phoſphorus; 23. Acidum perlatum; 24. Acid of Pruſſian blue; 25. Aerial acid; 26. Pure fixed vegetable alkali; 27. Pure fixed mineral alkali; 28. Pure volatile alkali; 29. Pure ponderous earth; 30. Pure lime; 31. Pure magneſia; 32. Pure clay; 33. Pure ſiliceous earth; 34. Water; 35. Vital air; 36. Phlogiſton; 37. Matter of heat; 38. Sulphur; 39. Saline liver of ſulphur; 40. Alcohol; 41. Æther; 42. Eſſential oil; 43. Unctuous oil; 44. Gold; 45. Platina; 46. Silver; 47. Mercury; 48. Lead; 49. Copper; 50. Iron; 51. Tin; 52. Biſmuth; 53. Nickle; 54. Arſenic; 55. Cobalt;

56.

56. Zinc; 57. Antimony; 58. Manganeſe; and, 59. Siderite.

These ſubſtances are, as it were, the heads of each column, at the top of which they reſpectively ſtand: to theſe thoſe that are placed below bear this relation, that the nearer they ſtand, the ſtronger attraction they muſt be underſtood to have. Every column, therefore, not only muſt exhibit every one of the fifty-nine ſubſtances which is capable of being combined with the principal ſubſtance at the top, but alſo the order which ſuch combinations follow. The double line diſtinguiſhes from the others the thirtieth ſtratum, which is the firſt that belongs to the dry way. The ſubſtances which occur in theſe rows refer alſo to the heads of the columns.

Lastly, I have diſtinguiſhed the horizontal rows, as well as the columns, by numbers on each ſide, that each rectangle might be more readily found and quoted. On account of the new ſubſtances, I am obliged to divide the table of ſingle elective attractions into two parts; and when, from multiplied experiments, more than two can contain ſhall require admiſſion, it may be conveniently divided into four parts; the firſt for the acids, the ſecond for the alkalis and earths, the third for the inflammables, and the fourth for the metals.

XII.

Column Firſt, the Vitriolic Acid.

CONCERNING the head of this column, as it is ſo well known, there is no occaſion to premiſe much. So firm is its compoſition, that its proximate principles have not yet been diſcovered. Some late excellent experiments * have been thought to diſcloſe the ſtructure of this acid; but they are, if I miſtake not, to be underſtood in a different manner. Sulphur, when burned in a veſſel filled with atmoſpheric air, and cloſed by means of mercury, abſorbs a portion of vital air, and yields an acid of twice or thrice the weight of the burned ſulphur. The acid, therefore, is ſuppoſed to have exiſted in ſulphur, far lighter, and without air. The ſame thing is confirmed by the efloreſcence of ſulphureous pyrites, which is converted into vitriolated iron, not however without the abſorption of a certain portion of vital air. To recover the air inherent in this acid, vitriolated mercury is reduced in a pneumatic apparatus by the aid of fire to its metallic form. During this operation, a large quantity of vital air, which is ſuppoſed to enter into the compoſition of the acid, is collected. Of theſe facts the following ſeems the true explanation. It has been fully proved by experiments, that every ſubſtance has a certain ſpecific quantity of fire, which yet varies more or leſs in one and the ſame, according to the different ſtates of ſolidity, liquidity, and fluidity, (XLVIII.). Now the vitriolic acid exiſts in a ſolid ſtate in ſulphur, but, on deflagration, deliqueſces, and therefore recovers the heat proper to its liquid ſtate. The ſpecific heat of ſulphur is to that of vitriolic acid as 0, 183 to 0, 758, that is, nearly as 1 : 4. But the acid extricated in this experiment contains very little water, only the quantity indiſpenſably neceſſary to fluidity, which it attracts from the air and the mercury, that almoſt always contain it. But the leſs water the acid contains, the leſs is its ſpecific heat, and it undoubtedly, in this caſe, is below 0, 758: let us ſuppoſe it to be 0, 549, and thus the proportion will be changed to 1 : 3. It follows, then, that the vital air enters into the compoſition of the ſpecific fire. It is evident, that it loſes its aerial form during the combination, which it cannot regain without a decompoſition, ſince, in other experiments, it may be expelled from acids by alkalis and other ſaturating ſubſtances, in the ſame manner as the aerial acid out of chalk; but the heat only is ſet at liberty, and no part of the vital air. That which appears in the reduction of vitriolated mercury perhaps ariſes from decompoſed heat, as we ſhall more clearly ſee in XLVIII. The principles of vitriolic acid have not yet therefore been ſatisfactorily ſet looſe; for as to the matter of heat, it exiſts in every body yet known.

---

* Lavoiſier's, in the Mem. of the Acad. of Paris, 1777.

Among the ſubſtances hitherto tried, vitriolic acid adheres moſt tenaciouſly to

2.] *Cauſtic terra ponderoſa*, which, when added to a ſolution of vitriolated tartar, generates the ponderous ſpar, which remains inſoluble at the bottom. The liquor contains cauſtic vegetable alkali, (Scheme 1.). Cauſtic or pure vegetable alkali is incapable of decompoſing ponderous ſpar.

3.] Next ſtands *cauſtic vegetable alkali*, which, when added in ſufficient quantity to a ſolution of Glauber's ſalt, yields vitriolated tartar and uncombined mineral alkali, which is unable to detach the vitriolic acid from vegetable alkali.

4.] Cauſtic *mineral alkali* precipitates the calcareous baſis of gypſum, but the inverſe experiment does not ſucceed.

5.] *Cauſtic calcareous earth* is ſuperior to magneſia; for vitriolated magneſia (Epſom ſalt) is immediately decompoſed in lime-water, and yields its acid to the lime. Moreover, lime ſeparates volatile alkali and all the metals from vitriolic acid.

6.] *Cauſtic magneſia* added to a ſolution of ſecret ſal ammoniac, ſeems to produce no change which is ſenſible to the ſmell; but if the mixture be kept for a few days in a cloſe phial, a diſtinct ſmell of volatile alkali will be perceived on opening it. The difference however of force is very ſmall; ſo that the ſmalleſt diminution of that of the former, or increaſe of that of the latter, inverts the attractions. Hence a precipitation of vitriolated magneſia is often effected by cauſtic volatile alkali: for the alkali cannot eaſily be obtained quite pure, being either, on the one hand, contaminated by a ſmall quantity of aerial acid, or, on the other, by quicklime, either of which effects a ſeparation, the former by means of a double (V.), the latter by a ſingle attraction. But the chief and perpetual cauſe of precipitation, is the formation of a triple ſalt, more difficult of ſolution, as we have before explained, (VIII.).

7.] *Cauſtic volatile alkali* precipitates clay from vitriolic acid, and zinc likewiſe, unleſs it be added in ſufficient quantity to rediſſolve the precipitate, (VII.). The ſame caution is applicable to the other metals; but there will be no ambiguity in the reſult, if the metal be inſoluble in the precipitate. See alſo what is ſaid of volatile alkali in XVI. and XXXIX.

8.] *Pure clay*, i. e. earth of alum, long digeſted in alkaline water, and then well edulcorated. I have already treated at ſufficient length concerning the precipitation of alum by zinc, iron, and ſome other metals, (VI.). But the metallic calces ſeem to have the ſame degree of attraction for acids as clay, at leaſt I have in vain tried to decompoſe vitriol of copper by clay; and reciprocally calx of copper tinges a ſolution of alum, and a white ſediment is depoſited; but this effect, as I have before explained, is owing to exceſs of acid.

9.—23.] This ſpace perhaps belongs to the *metallic calces*. In all the tables of attractions which have been publiſhed, and even in that which I offered to the world in 1775, the metals were placed in the columns of the acids; but upon farther reflection, I am forced to exclude them. That theſe ſubſtances are attracted and diſſolved by acids, is known even to beginners; but let it be remembered that they are not, as was ſuppoſed, taken up entire, and in their complete form by menſtrua: for ſome particles of the acid carry off the ſuperfluous phlogiſton, while others diſſolve the calcined metal. Since therefore they exiſt in the menſtruum mutilated, and in a great meaſure deprived of one of their principles, the condition under which the proceſs may be referred to ſingle attractions, does not exiſt. Hitherto the precipitations of metals by metals have been ill underſtood. When I obſerved many years ago, for the firſt time, that the ſeries of the metals was the ſame with reſpect to all the acids, I was ſtruck with great ſurpriſe at the coincidence, conſidering in how many particulars earths and alkalis differ with regard to them. I therefore began to entertain a ſuſpicion, that the precipitation of metals depended, not on the election of the acids, but on ſome other principle, which I now certainly know to be the attractive power of the diſſolved calces for the phlogiſton of the precipitating metal. I have elſewhere treated of this ſubject *, and ſhall ſay more upon it in the ſequel, (XLVII.). Complete metals therefore are properly excluded, but

---

* Diſſ. de phlogiſti quantitate in div. metallis, § 2.

are the calces alſo to be ſet aſide? They are really diſſolved; and it ſeems agreeable to the nature of things to ſuppoſe, that the ſame acid would find ſome difference in ſixteen different calces, in conſequence of which it would prefer ſome to others. But as reaſoning is fallacious, without the teſtimony of experience, I performed experiments with the calces, eſpecially with thoſe of ſilver and copper. I firſt procured as ſaturated a ſolution of ſilver in the nitrous acid as poſſible, which I could not indeed bring to ſuch exactneſs that it would not redden turnſole; but the exceſs can ſcarce be taken away without the precipitation of the metallic ſalt. To this ſolution I added copper calcined by fire, and expoſed it to a heat of digeſtion for ſeveral days; but though it was only very ſlowly diſſolved, and the colour of the liquor changed to a blue, no ſigns of precipitation appeared. Another ſolution of ſilver, equally ſaturated, diſſolved that calx of mercury which is uſually called precipitate *per ſe*, without any diminution of its tranſparency. I afterwards ſaturated nitrous acid with copper, and added the calx of ſilver precipitated by cauſtic fixed alkali; here there was only an inconſiderable ſolution, and no precipitation at all. It ſeems, therefore, that an acid takes up calcined metals without diſtinction, provided they have loſt a certain quantity of phlogiſton; for more or leſs of this principle makes a remarkable difference in ſome caſes. Beſides, when the nitrous acid is uſed, it ſometimes happens that a calx, in a proper ſtate, is gradually deprived of its phlogiſton beyond the determinate limit, and then it is immediately rejected. Such events, proceeding from the peculiar nature of certain ſubſtances, muſt be carefully obſerved, leſt erroneous concluſions ſhould be drawn. I have before obſerved,

ſerved, that the calces attract each other, particularly thoſe of zinc and copper *. Theſe combinations, when diſſolved in the ſame acid, produce, without doubt, triple ſalts, which deſerve farther examination.

I have inſerted the metallic calx in the order in which they are uſually precipitated, ſince it may not be without uſe to be acquainted with it; but I have obliterated the horizontal lines, in order to ſhew that the acids have not yet been found to poſſeſs any power of ſelection.

24.] I here place *water*, ſince it diſſolves moſt of the vitriols, and reſtores them unchanged. I am aware, indeed, that mercury, tin, biſmuth, and antimony, are ſeparated from the vitriolic acid, upon the addition of water; but it ſhould be obſerved, at the ſame time, that a large quantity is requiſite, which firſt carries off the exceſs of acid eſpecially neceſſary to theſe ſalts, and more ſlightly adhering to them, and then by the concurrence of heat ſeizes the remainder; but a proper quantity does not render the ſolutions turbid. We know that the vitriolic acid cannot be perfectly deprived of its ſuperfluous water by boiling, but that it retains more than one-fifth of its weight; which therefore is the leaſt poſſible quantity in metallic ſolutions. But by a ſufficient quantity of water, and in a certain length of time, all the vitriols perhaps may be decompoſed; in which caſe another place ſhould be aſſigned to it, unleſs ſome other cauſe exerts its influence at the ſame time.

---

* *Ibid.* § 5, d.

25.] *Phlogiſton* comes laſt, to which, however, ſome of the moderns give the firſt place; but I am as yet unacquainted with any experiment from which it can be ſafely concluded that phlogiſton, in the humid way, and by attracting the acid, is capable of decompoſing either neutral or middle ſalts, whether earthy or metallic. It is indeed ſtrongly attracted by the vitriolic acid, as appears from the dark colour which it contracts from the ſmalleſt portion of oily matter, whether this be uncombined or intimately united with ſome other ſubſtance; however, a ſufficient quantity of water both prevents the offuſcation, and removes it when it has been long preſent. Moreover, this acid, though in the moſt concentrated ſtate, does not affect the phlogiſton of charcoal, except by means of a proper degree of heat. Metals put into the vitriolic acid, loſe a certain portion of phlogiſton, but this is the effect of heat; at leaſt, of that degree which is excited by the ſolution; and I have before obſerved that this privation is neceſſary to ſolution, (V.) and ſhall bring farther proof in XIII.

31.] In the dry way, *phlogiſton* occupies the firſt place, for vitriolated tartar, Glauber's ſalt, ponderous ſpar, and gypſum, loſe their acid by the intervention of the inflammable principle of charcoal, and a ſufficient heat.

32.] It is probable, that *terra ponderoſa* decompoſes vitriolated tartar in this way; it remains, however, to be confirmed by experiment.

33.] *Vegetable alkali* expels the volatile.

34.] So does *mineral alkali*; but whether the latter yields to the vegetable has not yet been examined.

35.] *Lime*, as well as

36.] *Cauſtic magneſia* deprives ſecret ſal ammoniac of its acid.

37.] All the *metals* probably, or rather their calces, expel the cauſtic volatile alkali. Experiments have been made with lead, tin, copper, iron, *&c.*

38.] *Volatile alkali.*

39.] *Pure clay* cannot detach the acids from ammoniacal ſalts.

XIII.

Column Second, the Phlogiſticated Vitriolic Acid.

It was an emphatical and juſt obſervation of the ancients, that phlogiſton lent wings to vitriolic acid, which, though it requires an intenſe heat to be ſublimed before its union with phlogiſton,

giſton, afterwards evaporates ſpontaneouſly. The effects, however, vary wonderfully, according to the different proportions. For the acid, when fully ſaturated, conſtitutes common ſulphur; if it be combined with a ſmaller quantity, it generates aeriform vitriolic acid, known likewiſe by the name of vitriolic acid air, which, when collected in mercury, cannot be condenſed into a liquid by cold; is very light, not exceeding 000,246 in ſpecific gravity. It immediately diſſolves camphor, and extinguiſhes flame. An hundred grains of diſtilled water, ſcarce take up five of this aeriform acid; and I call this liquor, for the ſake of diſtinction, *phlogiſticated vitriolic acid.* This acid freezes in the ſame temperature as pure water; and what is remarkable, the acid elaſtic fluid remains in the ice, though in open veſſels it forſakes the water. What is highly worthy of notice, is, that if it be expoſed to heat in a tube hermetically ſealed for twenty days, a ſmall quantity of ſulphur is ſeparated. Has the decompoſition of heat any ſhare in this phænomenon?

The vitriolic acid, by the aid of fire, and properly treated, may be phlogiſticated by moſt ſubſtances containing the inflammable principle; but it cannot be reduced to this ſtate by means of aerial acid. The phlogiſton, in theſe operations, works wonderful changes, for a very fixed, heavy, inodorous, acrid liquor, becomes elaſtic, light, and ſo volatile, that its very penetrating ſmell threatens ſuffocation, and moreover ſo weak, that vegetable acid attracts alkali from it. I have not yet learned from experiment, whether there hence ariſes any variation in the elective attractions. I know that it diſſolves alkalis; that cauſtic fixed alkali, and pure lime expel volatile alkali; and alſo, that lime-water precipitates magneſia; and till the order of the other ſubſtances ſhall have been aſcertained, I follow the ſame as in the preceding column. The neutral and middle earthy ſalts, formed by this acid, differ a little in figure, taſte, and other properties, from thoſe which contain pure vitriolic acid; the difference, however, diſappears in time, for the phlogiſton gradually flies off.

BUT as all metals, in order to be ſoluble, muſt be deprived of a determinate portion of phlogiſton, which, for each, is various, (for none can be taken up in its reguline ſtate by vitriolic acid, without the ſeparation either of inflammable air, or aeriform acid; while, on the contrary, each, when deprived of a certain portion of phlogiſton, is not only more eaſily diſſolved without any farther loſs of phlogiſton, but likewiſe afford the ſame vitriols as in the preceding caſe;) hence it neceſſarily follows, that the phlogiſticated vitriolic acid ſhould reject them; and there are ſome experiments from which it would appear that it really is ſo. Zinc, which is quickly diſſolved in diluted vitriolic acid, is changed, by the ſame acid properly phlogiſticated, into a white powder, which ſeems neither to be taken up by vitriolic nor marine acid. Each particle of the menſtruum muſt be loaded with phlogiſton, otherwiſe thoſe which are free from it act at firſt in the uſual way; but when they are ſaturated, ſolution ceaſes. It is ſaid, that, by the aid of heat, the zinc is attacked, and that a quantity of inflammable air is extricated; but I have not yet ſeen this. Flowers of zinc are taken up by the phlogiſticated acid. Iron agrees with zinc, except that when it is too much calcined, it is ſcarce ſoluble. Copper is not viſibly changed in this menſtruum. Metallic precipitates procured by alkalis are by no means to be conſidered as reguli minutely divided; for they are more or leſs deprived of phlogiſton, as appears partly from what has been ſaid above, and partly from the ſediments thrown down by any metal uſed as a precipitant; which differ from the former both in ſplendour and nature; I have therefore no doubt but phlogiſticated vitriolic acid will diſſolve metals properly calcined; but I confeſs, that the particular phænomena have not been examined with proper attention. This volatile menſtruum cannot be ſubjected to experiments in the dry way.

XIV.

Column Third, Nitrous Acid.

1.] This acid, likewiſe, ſeems to have ſuch firmneſs of ſtructure, that its principles have not hitherto been aſcertained.

ed*. Expoſed to the fire with various ſubſtances, it yields a great quantity of vital air; but it remains as yet doubtful whether the air exiſted uncombined in the acid, or is formed by its being ſufficiently phlogiſticated. This queſtion will be diſcuſſed hereafter, (XLVI.). It exerts its elective attractions nearly in the ſame order as the vitriolic acid.

2.] *Cauſtic ponderous earth* cannot be ſeparated from nitrous acid by the cauſtic vegetable alkali. When the aerial acid is preſent, it is precipitated in conſequence of a double attraction; but if there be too much, it will be rediſſolved.

3.]

---

* The Count de Saluces politely ſent me his letter on the generation of nitre, but he has not yet publiſhed his proportions, and I have not therefore had the ſatisfaction of obſerving this ſpectacle. Mr Thouvenel, too, has very lately obtained the prize from the Pariſian Academy, for procuring nitrous acid from atmoſpheric air and putrid vapour.

3.] *Cauſtic vegetable alkali* decompoſes quadrangular nitre, and forms priſmatic.

4.] *Cauſtic mineral alkali* precipitates nitrated lime.

5.] *Lime* precipitates nitrated magneſia.

6.] *Cauſtic magneſia* expels the volatile alkali from nitrum flammans.

7.] *Cauſtic volatile alkali* precipitates clay, zinc, and the reſt of the metals.

8.] The place of *pure clay*, as alſo of the ſubſtances which follow has not been ſufficiently determined.

9.—24.] The *metals* properly calcined.

25.] Water ſeems to prevent the acceſſion of phlogiſton. The acid juſt expelled from nitre, by vitriolic acid, contains about two-thirds of its weight of water.

26.] The nitrous acid ſoon detaches from the metals that portion of phlogiſton which impedes ſolution; and when heat is employed, it ſometimes goes beyond proper bounds, inſomuch, that being too much calcined, they cannot be held in ſolution. Thus, tin and antimony are taken up with vehemence, but are ſoon let fall again to the bottom.

In the dry way, the ſame order as in column firſt, as far as I have yet been able to learn, is obſerved. Phlogiſton occupies the firſt rectangle, for in detonation the acid forſakes both ponderous earth and vegetable alkali to unite with phlogiſton. Whether it be converted into vital air, I do not here enquire, but the intenſity of the deflagration, even in vacuo, clearly ſhews the preſence of this air, which ſeems to be totally converted into heat; for nitre, in detonating with charcoal in cloſe veſſels, yields fixed and foul air, but ſcarce any thing fit for ſupporting ignition and reſpiration.

XV.

Column Fourth, the Phlogiſticated Nitrous Acid.

Nitrous acid, eſpecially when concentrated, eagerly attracts the inflammable principle, and, when contaminated with it, emits red vapours, and the liquor acquires a reddiſh colour, which, however, may be ſo far driven off by a ſlow diſtillation, that the liquor ſhall appear as limpid as the cleareſt water; ſuch an acid is juſtly called *pure*. But the colour which has been made to diſappear, returns upon the ſmalleſt addition of phlogiſton; even the ſolar rays induce a yellow colour, and cauſe the acid to emit yellow fumes, as Mr Scheele has obſerved. Smoking nitrous acid, moreover, furniſhes a fine proof, that different colours depend upon the different denſity of phlogiſton; for if nitrous acid, when red and concentrated, be diluted with about a fourth part of its bulk of water, it aſſumes a beautiful green colour, and yet emits red fumes; but an equal, or a greater portion of water makes it blue, while twice or thrice its bulk deſtroys all colour. The red ſmoke which riſes ſpontaneouſly, or may be driven off by heat, preſerves its elaſticity in a cloſe veſſel, and cannot be reduced to a liquid by cold; it is therefore properly called *aeriform nitrous acid.* It is abſorbed by water, which, with a certain portion, becomes blue; with a larger, of a beautiful green; when ſaturated, is yellow, and is then found to have received an increaſe of one-third of its bulk. Such are the variations of *phlogiſticated nitrous acid.* The blue ſpontaneouſly emits *nitrous* air, the green ſcarce any, and the yellow none at all. It well deſerves to be noticed, that nitrous air ſometimes exceeds the phlogiſticated acid from which it has been expelled, tenfold in bulk, though water cannot receive above one-tenth[*]. Yellow nitrous acid, expoſed to heat in a tube hermetically ſealed, becomes of a more intenſe colour, the green or blue is turned yellow; but by refrigeration the former hue is brought back. When the heat is continued for a long time, a colour permanent in the cold is acquired; the tinging matter may be expelled in the form of a red vapour, and the acid will remain without colour; but after refrigeration, the vapour again enters into the acid, un-

---

[*] Prieſtley.

leſs it be changed by a long continued heat *.

The phlogiſticated acid diſſolves alkalis and metals, but it adheres to them very looſely, (XXXVII.). A ſufficient quantity of acid, (unleſs it be quite ſaturated), in an open veſſel, is not much prevented by the phlogiſton from diſſolving metals, for the particles which are contaminated, or which attract this volatile ſubſtance, fly off; and moreover, this menſtruum attacks them on account of their inflammable part, and does not take up thoſe which are calcined beyond certain limits. The calx of mangane, known alſo by the name of magneſia nigra, furniſhes an admirable proof of the effects of a certain portion of phlogiſton; for this calx contains a very ſmall quantity of the inflammable principle, on which account a ſcarce ſenſible quantity is diſſolved

---

* Prieſtley.

ſolved by pure nitrous acid, unleſs upon the addition of ſugar, honey, or ſome other inflammable ſubſtance, capable of affording the neceſſary complement; but the phlogiſticated acid perfectly diſſolves it. Theſe ſolutions precipitated by alkalis afford a white powder, readily ſoluble in acids, but which, by heat, is turned black, and recovers the properties of magneſia nigra; the white ſediment, therefore, is nothing but the calx united with as much phlogiſton as is neceſſary to its ſolution in pure acids; but the regulus contains a ſuperfluous quantity, ſince red vapours are formed during its ſolution in nitrous acid. Mercury diſſolved in nitrous acid, in the cold, depoſits cryſtals ſpontaneouſly; by cauſtic volatile alkali, it is precipitated of a black colour, and differs in many other reſpects from that which, in conſequence of the application of heat, has loſt more of its phlogiſton. The ſame remark is applicable to iron, and ſome other metals. Every metal indeed muſt be deprived of a portion of phlogiſton; but if this proceſs is carried beyond certain limits, either no ſolution takes place, or one widely different from a real ſolution. The order of attractions, not having been ſufficiently explored by experiment, is adjuſted according to the preceding orders.

XVI.

Column Fifth, the Muriatic Acid.

1.] The acid of ſea ſalt is nothing but water more or leſs combined with marine or muriatic air. This air is properly denominated *aeriform marine acid*, of which diſtilled water is capable of abſorbing one half of its weight, and then yields *phlogiſticated marine acid*. The acid recently expelled by vitriolic acid from ſea ſalt, commonly contains threefourths of water. This acid ſeems to exert its attraction in the ſame way as the preceding, though indeed in ſome caſes more obſcurely.

2.] *Ponderous earth,* diſſolved in marine acid, cannot be expelled by pure vegetable alkali.

3.] *Pure vegetable alkali* expels the mineral. (See Scheme 3. and 32.).

4.] *Pure mineral alkali* expels lime, (Scheme 4.).

5.] *Pure lime* ſeparates magneſia, volatile alkali, and the metals.

6.] *Pure magneſia* is to be placed before volatile alkali, for the reaſon before mentioned. The acid, magneſia, and volatile alkali, in a proper quantity, unite and form a triple ſalt: hence, in order to attain the proper proportion, a little magneſia is always ſeparated on the addition even of the pureſt volatile alkali; but it is only the quantity neceſſary for attaining this end.

7.] *Pure volatile alkali* has no power againſt lime, (Scheme 5.); but the aerated precipitates it in conſequence of a double elective attraction, (Scheme 36.). It precipitates metals.

8.] *Clay.*

9.—24. *Metallic calces.*

25.] *Water.* (See XII.).

26.] We ſhall ſee in the next paragraph, the relation of *phlogiſton* to marine acid. Some of the ſubſtances adduced in the preceding columns are wanting in thoſe which follow, for all cannot be diſſolved in each menſtruum; but I leave the rectangles which otherwiſe would belong to them empty, that the difference may be the more ſtriking.

In the dry way, it may be preſumed, that the ſame order is obſerved as in 1. and 3. till experiments ſhall have ſhewn the contrary. I confidently preſume that the volatile metals, both with reſpect to one another, and thoſe which are fixed, have by no means the ſame action as in the humid way. Corroſive ſublimate is decompoſed by all the acids, in conſequence of a double elective attraction, as was above explained with reſpect to antimony; and this alſo is without doubt the caſe with lead, ſilver, and other metals ſaturated with acid of ſalt, which, when diſtilled with antimony, yield butter of antimony. If we are unacquainted with this cauſe, thoſe experiments of Mr Pott, which ſhew that corroſive ſublimate yields a butter with regulus of arſenic, and that, on the other hand, not a grain is obtained with white arſenic, are abſolutely unintelligible; but, when we are acquainted with it, there remains no obſcurity in theſe phænomena.

XVII.

Column Sixth, the Dephlogiſticated Marine Acid.

The illuſtrious Stahl reckons phlogiſton among the proximate principles of the nitrous acid. All the experiments which have been ſince made, ſhew, that this acid attracts the inflammable principle with great avidity; but we cannot hence draw any concluſion with reſpect to its compoſition, unleſs we are to believe an axiom in moſt inſtances falſe and contrary to phænomena, according to which, thoſe ſubſtances which contain ſome common principles of the ſame nature have a greater attraction than thoſe which are formed of principles altogether different. Martial vitriol is not ſoluble in ſpirit of wine, though a dephlogiſticated ley of it is very readily ſoluble, not to mention a great number of other inſtances. No one, at leaſt on this ground, ſuſpected the preſence of phlogiſton in marine acid, which ſo obſtinately rejected that volatile principle ; but this is now certain, from the diſcovery of the ingenious Mr Scheele *: for magneſia nigra, which we have before conſidered as almoſt deſtitute of phlogiſton, attracts it with ſo much force as to decompoſe the marine acid in a heat of digeſtion ; it is perfectly ſoluble in this acid, and is precipitated of a white colour from it, which ſhews the acceſſion of phlogiſton, (XV.). But the acid thus dephlogiſticated, conſtitutes an elaſtic fluid, of a light red colour, of the ſame ſmell,

---

* Stockh. Tranſactions, 1774.

ſmell, if the greater maſs be conſidered as hot aqua regia; it is not eaſily ſoluble in water, and ſcarce leaves an acid taſte, when made to paſs through it; but if it be confined over water for twelve hours, four-fifths are abſorbed, and the reſiduum conſiſts of common air: that which has paſſed through water is capable of making ſolutions, but the unwaſhed is the moſt efficacious. It ſhould therefore be collected in cylindrical phials, ſucceſſively adapted to the neck of the retort, which, when full, ſhould be cloſed with glaſs ſtopples. A little water is beforehand put into the phials to abſorb the muriatic air. Subſtances which are to be expoſed to it ſhould be put in with the ſtopples. It attacks phlogiſtic bodies with great vehemence; whitens all the colours of vegetables; reddens martial vitriol; diſſolves all the metals directly, and affords the ſame ſalts which are formed by the acid entire, which may alſo be affirmed with reſpect to earths and alkalis; it changes white arſenic to a liquid acid, (XX.); always regaining its original form when its loſs is reſtored; ſo that this truth is ſufficiently proved both analytically and ſynthetically. It ſhould be carefully noticed, that the red elaſtic fluid is properly entitled to the name of dephlogiſticated marine acid, and not the liquor in the receiver, which, although it has received a portion of the elaſtic fluid, yet conſiſts chiefly of common marine acid, (XVIII.).

THAT the dephlogiſticated acid ſhould form with alkalis, ſalts exactly like thoſe which contain the entire acid, is a proof that they contain ſome of the inflammable principle by which the deficiency is ſupplied. What I have ſeveral times before obſerved, concerning the neceſſity of depriving metals of a certain portion of phlogiſton, before they can be diſſolved in acids, is admirably confirmed by the power poſſeſſed by the dephlogiſticated marine acid, of diſſolving them all. This ſeems to take place according as the phlogiſton adheres more looſely to them; but whether the order is the ſame as that of the preceding acids, muſt be decided by future experiments. Its volatility prevents its action in the dry way.

As marine acid is already ſufficiently provided with phlogiſton, it refuſes a larger portion in its liquid ſtate; but in its aerial form, having a larger ſurface, and being freed from its aqueous cover, it ſeems to admit more; nay, even to attract it with avidity, and when ſufficiently ſupplied with it, to become inflammable. It may perhaps be ſuſpected that dephlogiſticated marine acid is nothing but the acid in an aerial form; on compariſon, however, I found a great difference, for the former is taken up by water ſlowly, not immediately; it does not become inflammable by decompoſing phoſphorus gradually, but attacks it inſtantly, reſolves it into white vapours, and regenerates aeriform marine acid; it melts neither ice nor camphor, effects no change either on nitre or alum, *&c.* That which is at firſt collected, while a diſtinct odour of aqua regia is perceived, from a mixture of muriatic acid, with half the quantity of magneſia nigra, by a gentle ebullition, contains about nine-tenths of common air; but that which is obtained towards the end, contains ſcarce one-eighth. The foul air which was mixed with the dephlogiſticated vapour, ſuffers a ſcarce ſenſible diminution from nitrous air.

XVIII.

Column Seventh, Aqua Regia.

We have now no difficulty in explaining why a mixture of nitrous and marine acids ſhould be capable of diſſolving gold, though neither of them of itſelf attacks this metal. Gold muſt firſt be deprived of a portion of phlogiſton, after which it is taken up by various menſtrua. Now the nitrous acid, ſeizing phlogiſton with great avidity, eaſily decompoſes the marine, whether it be diſengaged or united with any baſis, as appears both from the ſmell of hot aqua regia, which is exactly like that of the dephlogiſticated marine acid, and likewiſe from the effect, for this menſtruum, thus deprived of phlogiſton, can repair its loſs from any metal; in conſequence of which, gold becomes ſoluble, particularly in the marine acid, (XVII.). Hence cryſtals of gold, procured by ſea ſalt diſſolved in nitrous acid, (for the two acids uncombined ſcarce afford any), and freed by edulcoration from the heterogeneous matters adhering to them, are found to contain the marine acid only. In this proceſs, therefore, the nitrous acid has no other effect than to dephlogiſticate the real ſolvent, as much as is neceſſary: that acid, however, alone, when concentrated by long continued boiling, directly attacks the inflammable principle of gold, very ſubtilely divided, ſuch as occurs in the proceſs of parting; it then diſſolves the calx, and retains it ſo feebly, that it often falls down ſpontaneouſly, or in conſequence of ſhaking. And this is the true explanation of Mr Brandt's experiment, who found that gold was ſoluble in nitrous acid *. There is no need to conſider the other ſolutions by aqua regia

---

* Acta Stockh. 1748.

regia one by one; we may only obſerve, that this compound menſtruum does not always yield triple ſalts, for in thoſe caſes in which the nitrous or the muriatic acids can of themſelves effect a ſolution, the compounds commonly cryſtallize ſeparately, at leaſt in part.

THE elective attractions here alſo follow the order ſet down in the preceding columns.

XIX.

Column Eighth, Fluor Acid.

How this acid may be expelled from fluor by the vitriolic, has now been known for a conſiderable time *. When diſengaged, it always aſſumes and retains an aeriform ſtate, till it comes in contact with water, which abſorbs it as well as other aeriform acids; and we thus procure *phlogiſticated acid of fluor*, which gradually corrodes glaſs, extracting particularly the ſiliceous part. This acid, however, in its aerial ſtate, acts upon glaſs much more efficaciouſly, eſpecially if the vapours be hot, which, though they be loaded with ſiliceous earth, conſtitute a tranſparent elaſtic fluid. When it is diſſolved in water, it depoſits part of the ſiliceous earth under the form of a white powder, but the reſt remains diſſolved in the liquor. Let me enter into a ſhort diſcuſſion, and enquire whether this be an acid different from every other, or mere muriatic acid, modified by an earthy baſis. Peculiar properties diſtinguiſh it from every other acid, from the vitriolic and marine in particular, with reſpect to which doubts have ariſen; for when digeſted with a little calx of ſilver, and then depurated by gentle diſtillation, it does not form argentum corneum; nor with fixed alkali does it yield vitriolated tartar, or Glauber's ſalt, or digeſtive or ſea ſalt; with lime it regenerates fluor; with magneſia it forms a cryſtallizable ſalt; with terra ponderoſa, an effloreſcing compound, and with clay, a ſweet and viſcid ſalt, like jelly: it alſo diſſolves ſiliceous earth itſelf, which totally rejects all other acids, (XLIV.)

---

* Stockh. Tranſ. 1771.

It is indeed true, that this acid is generally adulterated with a little of the marine, whence, without doubt, the reſemblance of ſmell; but is the origin of the nitrous acid therefore to be deduced from the marine, becauſe both are preſent in aqua regia? How ſmall the portion of the acid of ſalt is, appears from the very ſparing precipitation of ſilver and mercury from the nitrous acid. The fluor acid, as far as I have yet found from experiment, neither derives its origin from the marine nor the vitriolic; at leaſt I cannot comprehend how the intimate union of an earthy baſis ſhould produce ſo wide a difference. We know that acids, in ſuch a combination, become in ſome degree milder, and loſe their acrimony. Why then ſhould the fluor acid, when reſolved into vapours, corrode, and ſometimes perforate even glaſs, a property belonging to no other yet diſcovered, with whatever baſis it may be united? If any one ſhould attempt to prove, from nitrated ſilver, *(lapis infernalis)*, corroſive ſublimate, and other metallic ſalts, that the natural acrimony of acids is heightened by combination with certain baſes, the opinion, if we examine into the matter cloſely, will appear to be groundleſs. It is clear, from an hundred inſtances, that the acrimony of acids is diminiſhed in proportion to their ſaturation; to ſuppoſe it increaſed is repugnant to the nature of the thing: beſides, an extraordinary degree of vehemence is aſcribed to theſe corroſive ſalts, becauſe they attack animal bodies when they come in contact with them. But the true cauſe of the corroſion is the dephlogiſtication of the metallic baſes, (XV. XVII.), which are for this reaſon capable of tearing away the inflammable principle contained in animal ſubſtances, for to this they always tend with great force; and thus they in ſome meaſure moderate their ſtrong attraction, for the acids are inſufficient to ſaturate them. The various hypotheſes concerning the origin of the nitrous and marine acids from the vitriolic, are well known, but they remain to this day unſupported by any valid argument, as will alſo hereafter appear, if I miſtake not, with reſpect to the fluor acid.

The preceding acids attract alkalis in preference to earths; but here a different order begins. Fluor acid, ſaturated with vegetable alkali, is decompoſed by lime-water, and yields fluor and uncombined alkali. The acids which abound in phlogiſton ſeem, for the moſt part, to prefer lime to alkalis. Ponderous earth, ſaturated with fluor acid, is ſoluble in a large quantity of hot water, and, upon the addition of lime-water, yields its ſolvent to the lime, an effect eaſily aſcertained, for the liquor is rendered turbid, and fluorated lime is depoſited. Fluor acid ſeems to take magneſia from vitriolic acid, but this does not hold with reſpect to lime; hence, therefore, the firſt place might be aſſigned to magneſia; but when I afterwards repeated the experiment, with all poſſible care, there was no appearance of precipitation. The ſediment, therefore, in the firſt experiment, was perhaps ſiliceous earth, which quitted the acid when it came to be diluted in the ſolution.

In the dry way, the order of this acid is made the ſame with the preceding, though it remains to be determined by experiment. It is certain, however, that fluor mineral is not decompoſed by cauſtic fixed alkali, (Scheme 51.), though aerated alkali effects a decompoſition; but it is in conſequence of a double elective attraction, (Scheme 63.).

XX.

Column Ninth, the Arſenical Acid.

That admirable diſcovery, which diſcloſed the compoſition of marine acid, at the ſame time points out a method of acquiring pure acid of arſenic. Macquer's arſenical ſalts indeed ſhew evidently the acid nature of white arſenic;

ſenic: the pure acid, however, could not be ſeparated before the method of dephlogiſticating the muriatic acid was brought to light. We are now acquainted with two ways. In the firſt, one part of pulverized black magneſia, and three parts of acid of ſalt, of which the ſpecific gravity to that of water, ſhould be as 5 : 4, are mixed in a tubulated glaſs retort, having a bulb capable of containing four times the quantity of the ingredients: to the retort a receiver is adapted, containing one-fourth of pulverized white arſenic, together with one-eighth of diſtilled water: the retort is to be heated in a ſand bath, and the manganeſe will quickly dephlogiſticate the marine acid, which again regains its complement from the white arſenic. The acid of ſalt being thus regenerated, unites with a portion of the water, and diſſolves part of the arſenic: the reſt of the water is ſeized by the arſenical acid, as it is gradually dephlogiſticated; ſo that the liquor of the receiver is divided into two ſtrata, and in a few hours all the arſenic diſappears: at this period the liquors ſhould be diſtilled to dryneſs in a retort. That which is collected in the receiver, conſiſts of butter of arſenic, and marine acid unmixed; but the white reſiduum in the retort, which ſhould be heated red hot to free it completely from acid of ſalt, exhibits real acid of arſenic in a ſolid form, (Scheme 17.), which is eaſily ſoluble in water.

The other method, is as follows: let two parts of pulverized white arſenic be diſſolved in a tubulated glaſs retort, in ſeven parts of marine acid, by ſlow boiling. Let the liquor collected in a receiver luted to the retort, be poured back, and at the ſame time three and one-half parts of nitrous acid, of the ſame ſpecific gravity as the above-mentioned marine, be added; then let a receiver be adapted again, but without a lute. By the aſſiſtance of the heat, the nitrous acid ſeizes the phlogiſton of the arſenic, and emits red fumes; but the diſtillation muſt be carried on till no more of theſe fumes are ſeen. Then, one part of white arſenic is to be added, which ſhould be in like manner diſſolved by gentle boiling, and afterwards one and one-half part of nitrous acid, which dephlogiſticates the diſſolved arſenic with effervеſcence, and red fumes ariſe. Laſtly, diſtil to dryneſs, and the reſiduum, after ſlight ignition, will be found to conſiſt of pure arſenical acid, which is fixed in the fire, attracts moiſture in the open air, and is ſoluble, if it be ſufficiently dephlogiſticated, in twice its weight of water. It ſhould be freed by thorough waſhing in a filter from the ſiliceous powder, which comes from the corroſion of the glaſs during ignition.

Arsenicated vegetable alkali is immediately decompoſed by lime-water, and the alkali is diſengaged. I have ſcarce any doubt but ponderous earth and magneſia prevail over alkaline ſalts; though I muſt confeſs that this conjecture has not been yet confirmed by experiment.

If acid of arſenic does not diſſolve metals in their complete ſtate, it at leaſt diſſolves them when calcined to a due degree. It is, moreover, to be obſerved, that no inflammable air is generated during the ſolution of iron; for the phlogiſton, being abſorbed by the acid itſelf, regenerates white arſenic.

XXI.

Column Tenth, Acid of Borax.

THE ſubſtance commonly called ſedative ſalt, is more nearly allied to acids than any other claſs of bodies. It reddens turnſole; ſaturates alkalis and ſoluble earths. It alſo diſſolves various metals, and has other properties which ſhew its acid nature; and it ſeems better entitled to the name of acid of borax, than that of ſedative ſalt.

DEPURATED borax may be decompoſed by boiling with lime; the acid forſakes the cauſtic foſſil alkali to ſeize the lime, and produces a ſalt ſcarce ſoluble. That the ſame thing takes place with vegetable alkali, ſaturated with acid of borax, is hitherto only a probable conjecture; as alſo on the addition

tion of ponderous earth and magneſia.

Acid of borax attacks metals with difficulty. The eaſieſt way to combine theſe ſubſtances is by a double affinity; but, to avoid miſtakes, the borax ſhould be ſaturated with ſedative ſalt, of which there is required ſomewhat above an equal weight, before the reaction of the alkali entirely ceaſes. I have dropped a ſolution of ſuch borax into metallic ſolutions, freed as much as poſſible from ſuperfluous acid. Gold, platina, biſmuth, and manganeſe, diſſolved in their proper menſtrua, remained undiſturbed; but ſolutions of mercury, lead, copper, iron, tin, nickle, cobalt, and zinc, were immediately rendered turbid, and yielded metallic ſalts of very difficult ſolubility, (Scheme 28.).

XXII.

Column Eleventh, Acid of Sugar.

Most vegetables ſhew manifeſt ſigns of acidity in their fruit or juices; and as the very few vegetable acids, which are known with tolerable accuracy, have different properties, the diligence of poſterity will certainly bring to light a great number. The chief obſtacle which prevents us from becoming acquainted with them, is the great difficulty of purifying them; for they are ſo involved in other ſubſtances, as ſcarce to admit of being extricated. I produce but a few here, of which the greater part labour under the imperfection of being deſtructible by fire. Do all of them agree in their primary principles? Can they be tranſmuted? Theſe queſtions muſt be determined by accurate experiments, made with this view. Of the acids of tartar, lemon, and milk, it is certain, that they all, upon the addition of ſpirit of wine and water, and after a digeſtion of ſeveral weeks, are changed into vinegar. At preſent they muſt be conſidered as different, ſince they can always be obtained perfectly the ſame, and poſſeſs properties perfectly diſtinct, conſtant, and of the utmoſt importance in chemiſtry.

The acid which exiſts in ſugar, is found to be ſo cloſely united with an oily matter, that it has never yet been poſſible to ſeparate it, but by the nitrous acid which deſtroys that matter. For this purpoſe, let ſix—eight parts of ſtrong nitrous acid be poured upon one of white ſugar, reduced to powder, in a glaſs retort, and be gently boiled. The nitrous acid in a ſhort time ſeizes the phlogiſton, and emits red fumes; after the ceſſation of which, the liquor remaining in the retort ſhould be poured into a large veſſel, and it will afford cryſtals of a priſmatic form, and very acid taſte. If the lixivium be dephlogiſticated by two—four parts of nitrous acid, it will again depoſit cryſtals of inferior purity indeed, but they may be purified by ſolution and repeated cryſtallization. This acid may be alſo obtained from honey, gum arabic, and ſpirit of wine, by means of the nitrous acid, but in ſmaller quantity. It poſſeſſes all the properties of acids in general; and beſides theſe, ſeveral peculiar to itſelf, by which it is diſtinguiſhed from all others. It totally differs from nitrous acid, and in many reſpects is of an oppoſite nature; ſo that its origin cannot with any degree of probability be aſcribed to that acid. But this queſtion is conſidered at greater length elſewhere *; the attractions

---

* Opuſc. vol. i. p. 251.

are the chief object of the preſent diſſertation.

It attracts lime moſt ſtrongly, and forms with it a ſaline combination, inſoluble in water, whence we may eaſily perceive the neceſſity of lime-water in the refining of ſugar. The juice of the ſugar-cane has an exceſs of acid, which prevents the concretion of the ſugar. For if this acid be added to a ſolution of perfect ſugar, it will not yield cryſtalline grains, but a glutinous maſs. Nothing can therefore be of greater ſervice than lime-water, which not only abſorbs the uncombined acid, but likewiſe forms an inſoluble ſalt, that either falls to the bottom or floats in the froth. Alkalis indeed ſaturate this acid, but they form ſalts which can ſcarce be ſeparated on account of their ſolubility.

Ponderous earth, magneſia, and alkalis, yield this acid to lime. It attacks almoſt all the metals. Its comparative power, with reſpect to other acids, will ſoon be ſeen in the columns of alkalis, earths, and metals. This acid is an excellent teſt for detecting lime any way diſſolved or ſuſpended in water, for the ſmalleſt drop of a ſolution of it immediately ſeizes the lime, forming with it a white inſoluble powder, which falls to the bottom. If we know the quantity of lime in a given weight of this ſaline powder, we eaſily learn, at the ſame time, the quantity of lime, in any caſe, from the ſediment, completely precipitated from a determinate quantity by means of this acid, carefully collected, waſhed, and weighed.

It cannot ſuſtain experiments in the dry way. The cryſtals alone, being expoſed to fire in a glaſs retort, partly indeed ſublime, almoſt unaltered, but the greater part is reſolved into an acid liquor, which will not cryſtallize, as alſo happens to the ſublimate, if it be again ſubjected to the operation. During this deſtruction of the acid, a great quantity of inflammable air and aerial acid is extricated. The acid of ſugar undoubtedly abounds with unctuous matter, yet it is of a very ſubtile nature, for in the fire it leaves no traces of charcoal or ſoot.

XXIII.

Column Twelfth, Acid of Tartar.

I HAVE above explained the nature of tartar, (IX.), and ſhall now briefly mention the proceſs for obtaining the acid pure. To an hundred parts of cream of tartar, diſſolved in boiling water in a tin boiler, let ſmall quantities of chalk, waſhed, dried, and pounded, be added at intervals. This muſt be continued as long as any efferveſcence is excited by the addition; about twenty-eight parts will be required. When the point of ſaturation has thus been attained, let the liquor be decanted and evaporated to dryneſs; it will yield fifty parts of tartarized vegetable alkali. The powder remaining in the bottom is lime ſaturated with the abundant acid of tartar, which, when waſhed and dried, amounts to above triple the chalk uſed, *viz.* an hundred and three. Let this compound be put into a phial, and let there be gradually added three hundred parts of vitriolic acid, containing two hundred and ſeventy of water, and thirty of the ſtrongeſt acid. Let the mixture be digeſted for twelve hours, and often ſtirred with a wooden ſpatula. Laſtly, let the clear liquor be poured off, and the reſiduum waſhed till it has loſt its acid taſte; let the water be filtered and added to the decanted liquor. We have here a ſolution of acid of tartar, which, if evaporated to dryneſs, affords near thirty-four parts of a cryſtalline maſs. To try whether it contains any vitriolic acid, let one or two drops of a ſolution of ſugar of lead be dropped into the diluted ſolution, a white ſediment will immediately fall down, upon which concentrated vinegar ſhould be poured, and it will ſoon diſappear, if it conſiſt of lead, ſaturated with acid of tartar; but vitriol of lead will not be diſſolved. Should ſome of this be detected, it ſhews that the acid of tartar is adulterated; but it may be eaſily purified by digeſtion with a ſmall quantity of tartarized lime. On the other hand, if too little vitriolic acid has been added, ſome acid of tartar will remain in the reſiduum, which is eaſily tried by throwing it on red hot coals; for pure gypſum neither grows black in the fire, nor emits an odour of ſpirit of tartar, which, however, happens, if it be contaminated with tartarized lime. A filtered ſolution of acid of tartar evaporated to dryneſs will gradually depoſit cryſtals in a cool place, which generally conſiſt of divaricating lamellæ.

If newly burned lime be uſed in the place of chalk, twice the weight of tartar will be totally decompoſed, and therefore there will be uncombined vegetable alkali in the liquor; but aerated lime can only abſorb the exceſs of acid, and the tartarized tartar will remain unaltered. An hundred pounds of purified tartar contains about twenty-three pounds of pure vegetable alkali, forty-three of ſaturating, and thirty-four of abundant acid. The difference of wines, and of proceſſes for purification, will doubtleſs occaſion ſome difference,

rence, but I have not yet been able to aſcertain the limits.

From what has been ſaid, it appears that lime, with reſpect to acid of tartar, has the ſuperiority over vegetable alkali, which is alſo true of ponderous earth and magneſia; for theſe earths, when deprived of aerial acid, and added to an exactly neutral ſolution of tartarized vegetable alkali, in a few minutes attract the acid of tartar in a heat of digeſtion; and evident ſigns of uncombined alkali appear on adding the proper teſts. Mineral and volatile alkali exhibit the ſame phænomena. To aſcertain whether lime or ponderous earth prevails, I dropped lime-water into a ſolution of tartarized ponderous earth, by which it was quickly rendered turbid, ſo that every doubt with reſpect to the ſuperior attraction of lime is removed.

Crystallized acid of tartar, when expoſed to fire, immediately grows black, and yields a ſpongy charcoal, which, however, ſoon turns white, if heated to incandeſcence, and is much contracted in bulk. When diſtilled from a glaſs retort, it affords, in the receiver, a phlegm ſcarce acid, together with oil; the carbonaceous reſiduum conſiſts of a portion of earth, which ſhews no ſigns either of alkali or acid. Hence, therefore, it appears, that there exiſts oil in this acid, which is deſtroyed in the fire, and is by no means convertible into fixed alkali. Treated with nitrous acid in the method above deſcribed, (XXII.), it afforded no acid of ſugar, and could not indeed be ſo much deprived of oily matter, as not to grow black in the fire. Some perſon is ſaid, however, to have ſucceeded in converting acid of tartar into acid of ſugar, which I have not yet been able to confirm by a repetition of the experiment,

riment. Acid of tamarinds, and perhaps of berberries, ſeem to agree in all reſpects with that under conſideration.

XXIV.

Column Thirteenth, Acid of Sorrel.

SALT of ſorrel is vegetable alkali ſaturated in exceſs with a peculiar acid, and therefore of the ſame nature as tartar. To obtain this acid pure, is a work of difficulty. The vitriolic, nitrous, and muriatic acids, attract indeed the baſis, but it is very hard to free the acid, thus ſet looſe, from all impurities. An hundred and thirty-ſeven parts of chalk perfectly decompoſe an hundred of this ſalt, attracting both the ſaturating and exceſſive acid. The clear liquor yields thirty-two parts of aerated vegetable alkali; nearly the ſame quantity as is obtained by fire. The ſediment contains *ſorrelled* or *oxalited* lime, which, after edulcoration and exſiccation, weighs an hundred and ſeventy-three. The component parts of this ſalt cannot be ſeparated like thoſe of tartar, for the acid of ſorrel takes lime from the vitriolic. Mr Scheele diſcovered another proceſs. He added the abundant acid of ſalt of ſorrel, ſaturated with volatile alkali, to a nitrous ſolution of terra ponderoſa ; an exchange of principles immediately took place, in conſequence of a double elective attraction ; and the ponderous earth, with the acid of ſorrel, a compound difficult of ſolution, fell to the bottom, (Scheme 25.). This ſediment is decompoſed by acid of vitriol, which prefers ponderous earth to every ſubſtance yet known ; and the acid deſired may be poured off ; but as it has been but lately diſengaged, its properties have been little examined. Meanwhile, it ſeems more nearly allied to acid of ſugar than of tartar ; it differs, however, from both, for the abundant acid of ſorrel forms, with vegetable alkali, ſalt of ſorrel, analogous to tartar, but decrepitating in the fire, fuſible, ſcarce turning black, and capable of being totally decompoſed by aerated lime,—properties not belonging to tartar. Now, ſaccharated vegetable alkali agrees neither with tartar nor ſalt of ſorrel.

I KNOW with certainty that acid of ſorrel prefers lime and ponderous earth to alkaline ſalts ; but it is as yet doubtful whether this be true of magneſia.

THIS acid is alſo deſtructible by fire, but it neither ſwells ſo much, nor turns ſo black as acid of tartar ; by diſtillation, a phlegm, far more acid than that which is ſeparated from tartar by this proceſs, but no oily matter, is obtained. Genuine ſalt of ſorrel, as it is found in the ſhops, varies not a little in the proportion

portion of its proximate principles. An hundred parts of ſome ſpecimens yield, on combuſtion and elixation, but thirty-one of vegetable alkali, while, to ſaturate the exceſs of acid, there is required an hundred and twelve and one-half. Others afford above thirty-ſeven, and require not above eighty-ſeven for ſaturation. It is obvious, that in the former caſe the ſaturated acid is to the abundant as 1 : 3½, but in the latter as 1 : 2½. The abundant portion is always larger than the ſaturated, which explains the ſtronger acidity of this ſalt compared with tartar. But the difference perhaps depends ſolely on the place where the ſorrel grows, or on the method by which the ſalt is extracted. The acid of ſorrel, (or more properly, perhaps, the *oxaline* acid), when procured by diſtillation, precipitates ſilver, quickſilver, and lead, from the nitrous acid; with alkalis, forms cryſtallizable compounds, and, by evaporation without

out addition, may be reduced to acid cryſtals.

XXV.

Column Fourteenth, Acid of Lemon.

Although the acid of lemon has been long known, it has been but ſuperficially examined. The expreſſed juice is to be freed from mucilage and fœculent matter, by a long ſubſidence, and ſhould then be expoſed to cold, that the watery part may be frozen. It ſeems to contain a little vegetable alkali, for upon dropping in acid of tartar, in a few days a ſmall quantity of tartar is found at the bottom. Stahl affirms that acid of lemon, ſaturated with crabs-eyes, and with the addition of a little ſpirit of wine, inſenſibly aſſumes, if it be kept in a phial ſlightly ſtopped, the nature of vinegar. An equal quantity of the ſame juice of lemon requires, for its ſaturation, of pure vegetable alkali ſixty-nine parts, of pure mineral fifty-one, and of volatile twenty-five. Theſe compounds do not eaſily cryſtallize.

It remains to be determined, by a greater number of experiments, whether acid of lemon certainly prefers lime, ponderous earth, and magneſia, to alkalis.

The acids of fluor, arſenic, borax, ſugar, tartar, ſorrel, and phoſphorus, agree in this reſpect, that if they be ſaturated with earths they are ſcarce ſoluble in water; and, therefore, if ſmall quantities of earth be added, the ſolutions remain clear, on account of the exceſs of acid, but near the term of ſaturation they become a little turbid; and when this is attained, all that was diſſolved is inſtantly precipitated, and can ſcarce be again diſſolved but by exceſs of acid. The ſame thing is perhaps true of ſome other acids, but not of all.

XXVI.

Column Fifteenth, Acid of Benzoin.

THE reſin, which, in the ſhops, paſſes by the name of *benzoin*, or *aſſa dulcis*, contains an acid ſalt, which may be ſeparated by ſublimation, and concretes into cryſtalline filaments or ſpiculæ. It may be acquired in the humid way more free from oily matter, by extracting the acid with lime, and then ſeparating the compound with muriatic acid *. The acid of benzoin being diſlodged, falls to the bottom, uncombined, and more difficult of ſolution than when united with the lime.

---

* Scheele in the Stockholm Tranſactions, 1775.

Boiling water takes up one twenty-fourth of its weight; but at the ordinary temperature ſcarce more than one five-hundredth. The taſte, approaching to that of ſugar, gives a ſlight ſenſation of acrimony, but none of acidity. It, however, reddens tincture of turnſole.

Spirit of wine readily diſſolves it, even without heat.

It is totally reſolved by fire into white vapours: it is, however, fuſible with ſmoke, on the ſudden application of a ſufficient heat; but can ſcarce be inflamed without the actual contact of ſome burning ſubſtance.

It readily combines with alkaline ſalts; but none of the compounds, except that with mineral alkali, afford cryſtals, that are not liable to deliqueſcence.

Lime-water, dropped into the ſolutions, precipitates the alkaline baſes, as alſo magneſia and clay. Lime, therefore, exceeds them in attractive power, but it is unable to ſeparate ponderous earth; nor does the latter, when burned and diſſolved in water, precipitate lime united with acid of benzoin; ſo that here a combination of three ingredients ſeems to take place.

The earthy ſalts, containing acid of benzoin, are with difficulty diſſolved in water, eſpecially thoſe that contain the ponderous and calcareous earths.

XXVII.

Column Sixteenth, Acid of Amber.

A crystallized volatile acid may be obtained from amber, by diſtillation, together with an acetous liqour and an oil. The acid may be in ſome meaſure purified by ſolution, and a ſecond cryſtallization. That which I uſed in the following experiment was thus prepared; it ſhews evident ſigns of acidity.

COMBINATIONS of this acid with alkalis may indeed be made to cryſtallize, but they are all deliqueſcent, except that into which the mineral alkali enters. Lime and ponderous earth afford ſalts of difficult ſolubility; clay yields cryſtals, and magneſia a compound like gum.

THE metals, when duly dephlogiſticated, are ſoluble in this acid, and for the moſt part they afford permanent cryſtals.

PONDEROUS and calcareous earths, and magneſia, take this acid from alkalis. Ponderous earth alſo precipitates ſuccinated lime and magneſia; lime-water makes no change in the ſolution of ſuccinated ponderous earth, but it diſtinctly prevails over magneſia.

XXVIII.

Column Seventeenth, Acid of Sugar of Milk.

BARTHOLET firſt mentioned ſugar of milk in the year 1619 *, but no one till Mr Scheele gave a complete analyſis of it †. An hundred parts of this ſalt yield fifteen and one half parts of acid of ſugar, and of another acid hitherto found only in ſugar of milk, and which is here to be conſidered about twenty three and one half.

---

* Encyclop. Hermetico-dogmatica.

† Stockh. Tranſ. 1780.

THIS acid is obtained in the form of a white powder, and is not eaſily ſoluble in water, for ſixty parts of boiling water take up but one of the acid. The ſolution turns turnſole red.

IN combination with alkaline ſalts it forms compounds far more ſoluble indeed, but ſtill requiring a weight of boiling water many times exceeding the ſolvend. The compounds formed by this acid and earths, are ſcarce ſoluble at all. As to attractions, alkalis obſerve the uſual order. Ponderous and calcareous earths, and magneſia, are ſuperior to alkalis, but it is difficult to determine the ſuperiority among them, as they are ſcarce ſoluble.

XXIX.

Column Eighteenth, Diſtilled Vinegar.

THIS acid, produced, during fermentation, from the preceding, which may in ſome meaſure be denominated crude, differs from them in the great inferiority of its attractive power for earths and metals; but, on the other hand, exceeds them in ſubtilty, not being altered by diſtillation. Vinegar alſo contains phlogiſton, but more intimately combined, or at leaſt more concealed. It has been mentioned above that acid of tartar, digeſted with water and ſpirit of wine, affords vinegar. B. de Vigenere long ago obſerved, that cryſtals of tartar ſometimes form in vinegar*. An acid alſo, very nearly reſembling vinegar, may be procured by diſtillation from guaiacum and birch, from wax, ſugar and amber, which is not to be confounded with acid of ſugar, and ſalt of amber.

---

* Du feu & du ſel, cap. 35. 1608.

Pure lime cannot detach vinegar from fixed alkali, and it therefore ſeems to reſemble the vitriolic, nitrous and muriatic acids in its attractions; and I have diſpoſed them in the ſame order, though the priority of ponderous earth has not yet been confirmed by experiments.

I conjecture, that, in the dry way, the ſame ſeries, as in the fifth column, prevails, till I have leiſure to confirm or correct this opinion by experiment.

XXX.

Column Nineteenth, Acid of Milk.

To obtain the acid of milk, curdled by ſpontaneous aceſcency, let the whey be collected and evaporated to one-eighth. This reſiduum is to be ſaturated with lime, that the phoſphorated lime may be ſeparated; then let the calcareous earth that has been diſſolved be precipitated by acid of ſugar; and at laſt by highly rectified ſpirit of wine, the acid of milk is obtained free from the phoſphorated lime, ſugar of milk, vegetable alkali, and mucilage which milk contains *.

This acid ſeems to be intermediate between vinegar and acid of ants; it, however, exceeds vinegar in attractive power. By the addition of ſpirit of wine, it is really changed into vinegar, after a month's digeſtion.

---

* Scheele, Act. Stockh. 1782.

With the alkalis, it forms deliqueſcent ſalts, and alſo with the earths, among which magneſia, contrary to what would be expected, forms the moſt permanent combination. Scarce any metal, beſides zinc, forms cryſtals with this acid; not even lead, which yields a ſweet ſolution, and depoſits ſome vitriolated lead.

With reſpect to alkalis and earths, the order of attractions is the ſame as that of vinegar.

XXXI.

Column Twentieth, Acid of Ants.

This acid approaches very near vinegar; they differ, however, in many reſpects. The former forms with magneſia, zinc, and iron, cryſtallizable ſalts; the latter only deliqueſcent. Its combination with magneſia is peculiarly remarkable [*].

Its attractions have hitherto been very imperfectly examined; in the mean time, as far as has hitherto appeared, this acid obſerves the ſame order as vinegar; which, however, is weaker, as the following columns ſhew.

All the acids of vegetables, as well as that of ants, may be totally reſolved into an elaſtic fluid, conſiſting partly of aerial acid, and partly of inflammable air.

XXXII.

---

[*] Opuſc. vol. ii. p. 389.

XXXII.

Column Twenty-firſt, Acid of Fat.

The celebrated Crell, by repeated diſtillations of fat, obtained from 2 lib, $14\frac{1}{8}$ ounces of oil, of charcoal $10\frac{19}{24}$, and of acid $7\frac{1}{4}$ *.

The ſalts formed by this acid, ſaturated with alkalis and earths, are very like thoſe that vinegar generates with the ſame baſes. Alkalis yield it to earths. A compariſon of this with other acids will be found in the ſequel.

XXXIII.

---

* Chemiſche Journal.

XXXIII.

Column Twenty-ſecond, Phoſphoric Acid.

Another acid which pervades all the kingdoms of nature, is eſpecially obtained from human urine, by collecting the ſubſtance, uſually called microcoſmic ſalt, and fuſing it in the fire: but it is to be obſerved, that this is a triple ſalt, and always contains two acids, the phoſphoric and *perlatum*, which ſhall be immediately more fully deſcribed, together with volatile alkali. When the acid is obtained in water by ſlowly burning phoſphorus in the air, it abounds with phlogiſton; which however, in an open veſſel, is gradually diſſipated: it thus becomes much fitter for aſcertaining attractions than the former; for the preſence of perlate acid in that, may give riſe to a diverſity in the decompoſitions.

The acid of phoſphorus prefers lime to alkalis; and therefore alkalis united with it, are immediately rendered turbid by lime-water, and a ſaline powder, very difficultly ſoluble in water, is gradually depoſited, conſiſting of lime ſaturated with phoſphoric acid. As phoſphorated vegetable alkali can receive an exceſs of acid, I ſuſpected that this exceſs only might produce the precipitation with lime-water, and that the neutral compound might remain entire; but I decompoſed the whole with a ſufficient quantity of lime-water, and nothing but an alkaline liquor was left. Phoſphorated lime is indeed precipitated by alkali, but not in conſequence of a ſuperior elective attraction. This ſalt is not ſoluble in water without an exceſs of acid; and whatever takes away the medium of ſolution, as in the preſent caſe the alkali does by ſaturating it, cauſes a precipitation of phoſphorated lime: aerated alkali, however,

ever, decompoſes it by means of a double attraction; and aerated lime falls down, (IX.). In ambiguous caſes of this kind, we muſt form our concluſion from the decompoſition of that ſalt which is more eaſily ſoluble. Thus, the preſent queſtion is anſwered by the precipitation of phoſphorated alkali by lime-water, and not by that of phoſphorated lime by alkali. The ſuperior power of magneſia and terra ponderoſa is not yet aſcertained with ſo much certainty.

In the dry way, I place lime before magneſia and ponderous earth, ſince the former undoubtedly diſpoſſeſſes fixed alkalis, which is not yet certain concerning the latter.

XXXIV.

Column. Twenty-third, Acidum Perlatum.

In 1740, Haupt found a ſalt in human urine, and deſcribed it under the title of *ſal mirabile perlatum*; it is the ſame which Margraaf mentions as altogether unfit for generating phoſphorus with powdered charcoal. Nevertheleſs, many have ſuppoſed, that this ſalt, which occurs in urine with the microcoſmic ſalt, contains the phoſphoric acid, and have explained its rejection of phlogiſton from the ſuperior attraction of foſſil alkali. But Mr Prouſt has lately diſengaged the ſubſtance, which alone performs the office of an acid in *ſal perlatum*; in microcoſmic ſalt, indeed, it is united with the phoſphoric acid. He digeſted ſal perlatum in diſtilled vinegar, brought it to afford cryſtals, and precipitated from the mother ley, by ſpirit of wine, a thick liquor, which, after being well waſhed in ſpirit of wine, and then diſſolved in diſtilled water, yielded an acid * which I call the *perlate*, till a more accurate examination ſhall ſuggeſt a better name. Mineral alkali, if I miſtake not, covers the acid. The cryſtallization, taſte, reaction, and effloreſcence, point out an exceſs of alkali. Perhaps this exceſs prevents ſpirit of wine, which rejects no acid, from extracting the acid part. It fuſes with ebullition, and appears pellucid, but when cooled it becomes opaque: it is taken up by acids, and may be ſeparated by ſpirit of wine: it exiſts with the phoſphoric acid, as well in bones as in microcoſmic ſalt.

It certainly prefers lime, ponderous earth, and magneſia, to alkalis. With mineral alkali, it regenerates ſal perlatum.

---

* Rozier's Journal.

It would be a peculiar and highly remarkable phænomenon, if a neutral compound, by means of an intimate union with phlogiſton, could act as an acid without decompoſition. This, however, ſeems to be the caſe with ſedative ſalt, and ſtill more certainly with the acid of Pruſſian blue, which will be deſcribed below. That obtainable from ſal perlatum, is, if I miſtake not, of the ſame nature. By means of a ſtrong impregnation of phlogiſton, it is ſo cloſely combined with a certain portion of foſſil alkali, that we have not as yet been able to effect a ſeparation of the principles; and what well deſerves notice, the compound, as a ſimple acid, takes up alkalis, earths, and metals, though ſeveral properties plainly indicate an exceſs of alkali. Meanwhile till their nature is better aſcertained, I conſider them as acids, ſince they ſeem to approach neareſt to theſe ſubſtances.

XXXV.

Column Twenty-fourth, Acid of Pruſſian Blue.

I HAVE long conjectured, not without reaſon, that the tinging matter in Pruſſian blue is of an acid nature, as it forms compounds of an intermediate kind with alkaline ſalts, as well as with earths and metals. Mr Scheele has lately taught us how to ſeparate the acid in a pure ſtate *. Phlogiſticated alkali, as it is commonly called, is a triple ſalt; containing the tinging acid, ſaturated partly with iron, and partly with alkali. This ſalt, boiled in a retort with weak vitriolic acid, emits the tinging acid in an inflammable aerial form, which may be abſorbed by water placed in the receiver. And as at the ſame time, ſome vitriolic acid paſſes into the receiver, the liquor ſhould be again diſtilled with a little chalk, till one-fourth ſhall have paſſed over; which is a ſolution of the preſent acid in water. The following proceſs anſwers the ſame end with leſs trouble: let ſixteen parts of Pruſſian blue be boiled in a cucurbit, with eight of mercury, calcined by means of nitrous acid, and forty-eight of water, for a few minutes, with conſtant agitation. The mixture becomes of a cineritious yellow; it ſhould be put on the filter, and the reſiduum elixated with boiling water. To the filtered liquor, let twelve parts of pure iron filings be added, and three of concentrated vitriolic acid. After a ſhaking of ſome minutes, the whole maſs is turned black by the reduced mercury. After the ſubſidence of the powder, the clear liquor is to be decanted into a retort, and one-fourth abſtracted.

---

* Act. Stockh. 1782.

This acid, in ſome reſpects analogous to the perlate, is diſtinguiſhed by a peculiarly diſagreeable taſte and ſmell, and conſiſts of aerial acid, volatile alkali, and phlogiſton. It ſpeedily flies off in an open veſſel: it ſeems to prefer alkalis to earths. Its forcible attraction for metals will be more particularly conſidered in the ſequel.

XXXVI.

Column Twenty-fifth, the Aerial Acid.

Of this acid, which is common to all the kingdoms of nature, I have treated at length in another eſſay, and have particularly examined its attractions in § 20.[*]. I ſhall now add only a ſhort compariſon of it with phlogiſticated vitriolic acid, ſince they are wretchedly confounded by ſome, who find it more eaſy to burden natural philoſophy with feigned hypotheſes, than to enrich it with accurate experiments. I have ſaid above, that phlogiſton, united with vitriolic acid, in different proportions, produces either vitriolic acid air, which, when abſorbed by water, is called phlogiſticated vitriolic acid, or ſulphur, (XIII.).

---

[*] Opuſc. vol. i. p. 43.

PHLOGISTICATED VITRIOLIC ACID has a moſt penetrating ſmell;—ſaturated with vegetable alkali, generates the ſulphureous ſalt of Stahl; the cryſtals ſpiculæ indiſtinctly hexangular; — they detonate with nitre;—may be totally ſublimed by a proper application of heat;—do not efferveſce with other acids; — gradually loſe their phlogiſton, and are at laſt ſpontaneouſly changed into vitriolated tartar.

THE AERIAL ACID has no ſmell;—with vegetable alkali, forms aerated alkali; the cryſtals quadrangular priſms;—they do not yield a ſpark with nitre;—are fixed;—emit conſtant numberleſs air-bubbles, till the ſaturation is complete, even with phlogiſticated vitriolic acid, to which the aerial acid is inferior in attractive power; — remain unchanged, unleſs fire or ſome ſtronger acid expel the weak aerial acid.

Hence let thoſe who are ſkilled in chemiſtry, and regard truth, form a judgment. If any one ſuppoſes other combinations of vitriolic acid with phlogiſton, beſides thoſe mentioned above, he muſt prove the mode of their formation, not by opinions, but by experiments.

A simple experiment proves that the aerial acid is attracted by atmoſpheric air; for if a phial filled with the former be ſet in an open place, where the ambient fluid undergoes no agitation, it will be found to contain atmoſpheric air only. Nay, aerated water yields its volatile acid to the atmoſphere.

XXXVII.

Column Twenty-ſixth, Cauſtic Vegetable Alkali.

HAVING examined the attractions of the acids, we now come to the alkalis, which are commonly combined with aerial acid, but when freed from this, are called cauſtic, or even pure; and it is in this ſtate only that they can be employed for the preſent purpoſe, for, when aerated, they give riſe to double affinities; ſee Schemes 1—8. 32—36. 46. 51. 62. and 63. Thoſe which are properly called ſaline, are of three kinds. The firſt is denominated vegetable alkali, being all obtained from this kingdom; and of this only I ſhall ſpeak in the explanation of column twenty-ſixth.

The vegetable alkali adheres moſt ſtrongly to vitriolic acid, for it not only is not diſlodged by either of the others, but takes this acid from them. In what manner nitre and ſea ſalt effect a partial decompoſition of vitriolated tartar, and the acid of tartar, likewiſe of nitre and digeſtive ſalt, I have explained above, (IX.), and in Scheme 9. 10. and 11. have ſymbolically repreſented the partition of the acid by darts.

The ſecond place belongs to the nitrous, (VI.), and the third to the marine acid. Whether the aeriform muriatic acid is capable of decompoſing nitre, has not been ſufficiently tried. In order to account for the order of the other acids, it will be proper to mention the chief experiments.

The celebrated Crell has admirably ſhewn, that the acid of fat is neither expelled by the acids of fluor nor of phoſphorus. That of fluor dropped into a ſolution of phoſphorated vegetable alkali, immediately precipitates a triple ſalt, conſiſting of fluor acid, vegetable alkali, and flint *. I dropped arſenical acid into a ſolution of phoſphorated vegetable alkali; after the mixture had ſtood twenty-four hours, ſpirit of wine precipitated the phoſphoric ſalt in no reſpect altered, and the acid of arſenic remained in the ſpirit. Therefore the phoſphoric is the ſtronger. The acid of tartar decompoſes all the ſalts which contain vegetable alkali, as far as I have tried, as the combinations of this baſis with the vitriolic, nitrous, marine, ſaccharine, phoſphoric, and arſenical acids, ſome completely, but others only in part, (IX.). To diſcover, therefore, its real power, acid of tartar ſhould be dropped into ſolutions of mineral alkali, combined with the ſeveral acids,

---

* Opuſc. vol. ii. p. 34. 37.

acids. For this alkali attracts the acids in the ſame order as the vegetable, without acquiring any exceſs, by which the obſerver might eaſily be miſled. The acid of ſugar ſeems more powerful than that of tartar; thoſe of ſorrel, lemon, and amber, weaker; but their order with reſpect to each other has not yet been ſufficiently aſcertained. Next follow the acids of ants, milk, and benzoin, which are ſtronger than vinegar. Acid of borax is expelled by vinegar, as alſo the perlate acid, the nitrous and vitriolic fully phlogiſticated. The aerial yields almoſt to all; it however precipitates ſolutions of flint, ſulphur, and oil; it even expels the acid of Pruſſian blue. Vegetable alkali takes up copper and tin, but their places are uncertain.

In the dry way, the acids of phoſphorus, borax, arſenic, and perlatum, are ſuperior on account of their fixity, (IV.): the reſt, except thoſe that are deſtroyed by ſtrong heat, obſerve the ſame order as in the moiſt way. Pure earths coaleſce with alkalis in heat, but in what order is uncertain; nor can it be eaſily aſcertained, ſince when any one is united by fuſion with alkali, it is not precipitated by the addition of another, but both combine with the menſtruum, and form an homogeneous maſs. The ſame thing holds with reſpect to ſulphur.

XXXVIII.

Column Twenty-ſeventh, Cauſtic Mineral Alkali.

THIS fixed alkali has received the name of mineral, from the great quantity of it which occurs in the mineral kingdom; it is alſo found in plenty in ſome vegetables growing in the ſea, or in a ſalt ſoil. It differs from the preceding, being both weaker, (XII. XIV. XVI.), and generating different ſalts with the ſame baſes. The acid of tartar does not in any reſpect change ſea ſalt, (Scheme 12.), which affords an eaſy method of diſtinguiſhing it from digeſtive ſalt. For the acid of tartar is the beſt teſt yet known for detecting the preſence of vegetable alkali in any mixture, as it decompoſes all the ſalts which have this baſis, ſome totally, others only in part, (IX.). This decompoſition is denoted by the depoſition of tartar, which, if the doſe of alkaline ſalt be conſiderable, and the ſolution concentrated, becomes perceptible in an inſtant: a ſmaller quantity, eſpecially in a weaker ſolution, requires the ſpace of a day or two.

As to the order of attractions repreſented in this column, I have not found it to differ from that in the thirty-ſeventh. This acid more certainly ſhews the true order with reſpect to acid of tartar, and in certain caſes more diſtinctly, as the compounds are more difficult of ſolution than thoſe containing the vegetable alkali. This is often advantageous in determining the attractions. Scheme 13. ſhews the decompoſition of borax by nitrous acid; Scheme 42. of ſea ſalt by the ſame, and 43. by acid of arſenic.

XXXIX.

Column Twenty-eighth, Cauſtic Volatile Alkali.

The order of attractions for acids ſeems to be the ſame in this inſtance as that of the fixed alkalis; but the volatile alkali takes up ſeveral metals, which are left untouched by the others.

That zinc precipitates the other metals, when diſſolved in volatile alkali, is certain, (Scheme 18.), and for the ſame reaſon as thoſe which are diſſolved in acids; a reaſon that has been formerly mentioned, and will be farther illuſtrated hereafter, (XLVII.); on this account I have placed them in the ſame order as in the columns of the acids, till experiment makes us acquainted with a better.

THE influence of phlogiſton on the ſolution of metals in acids, has been ſhewn above in various inſtances, (V. XIII. XV. XVII.); let me now conſider ſome combinations of volatile alkali. To cauſtic volatile alkali let ſome filings of copper be added; if the phial be quite full and be immediately ſtopped, no ſolution will take place, but if a little ſpace above the liquor be left to the air, or the phial remain open for a quarter of an hour, in a few days a ſolution will be obtained as colourleſs as water; but if the ſtopple be taken away, it ſoon grows blue at the ſurface, and the ſame tinge gradually pervades the whole maſs. A ſolution thus coloured may be ſoon procured in an open phial. The ſolution loſes its colour, if new filings be added, and the phial be kept cloſed for twenty-four hours. Theſe remarkable variations depend on phlogiſton: copper is inſoluble in its metallic form, but it is very ſoluble when a little of the inflammable principle is extricated. Such a privation is effected in a veſſel, either open, or only filled in part, by means of the air which ſtrongly attracts this principle, as will be ſhewn hereafter, (XLVII.), and the effects will vary in proportion to the quantity. If juſt as much is carried off, as is neceſſary to render the copper at all ſoluble, the ſolution will be colourleſs; but if it be farther deprived of phlogiſton, the calcined copper yields a blue ſolution, which is obvious even to the eye, for the colourleſs ſolution is ſoon deprived of phlogiſton, by being expoſed to the air, and therefore immediately begins to turn blue, upon coming into contact with the air. On the other hand, the blue ſolution loſes its colour, in the way above mentioned, ſince the alkali more willingly attacks copper but a little dephlogiſticated, than that which is much calcined. The force with which volatile alkali attracts dephlogiſticated copper, promotes the effect of the air.

Volatile alkali detonates with nitre, whence it manifeſtly appears to contain phlogiſton, and that as a proximate principle, which is ſeparated by the calx of manganeſe, quickſilver, gold, and various other ſubſtances, in conſequence of a ſtronger attraction; and then an elaſtic fluid, of a peculiar nature, is obtained, which probably is the other principle: I ſay *probably*, for it has not yet been reduced to volatile alkali by the addition of phlogiſton. Moreover, in this decompoſition it deſerves to be remarked, that no ſigns of vegetable alkali occur, ſince many contend that the volatile originates from the vegetable, intimately combined with phlogiſton.

In the dry way, the attractions of volatile alkali ſeem to differ from thoſe immediately preceding in this, that it may be expelled by fire alone, when united with certain fixed matters; and on this account I have thought proper to exclude them entirely.

XL.

Column Twenty-ninth, Cauſtic Ponderous Earth.

The celebrated Margraaf aſſerts that the baſe of ponderous ſpar is calcareous earth, and indeed experiments ſhew that they agree in various properties; but Dr Gahn and Mr Scheele, by a more particular inveſtigation, detected a great difference between them, and from my experiments it appeared to be ſtill greater. Both agree in efferveſcing in acids; in loſing the aerial acid, when expoſed to fire, and thus acquiring ſolubility in water, and affording a cream in the open air; in rendering alkalis cauſtic, and in diſſolving ſulphur, *&c.* But they differ widely at the ſame time; for gypſum is lighter, and totally ſoluble in water, but ponderous earth forms with the vitriolic acid ponderous ſpar, of which the ſpecific gravity is 4,500, and which can ſcarce be at all diſſolved in water; with nitrous and marine acids lime forms only deliqueſcent ſalts, but ponderous earth difficultly ſoluble cryſtals; lime ſaturated with acetous acid affords cryſtals, but ponderous earth an almoſt deliqueſcent ſalt: finally, they differ widely in their attractions, as is evident from the preceding obſervations, and will now be made to appear more clearly.

THIS earth is but ſparingly ſcattered over the ſurface of the earth, and has hitherto been found only in combination with the vitriolic acid; a combination ſo cloſe that it can ſolely be deſtroyed by the phlogiſton of oils and charcoal, with the aſſiſtance of fire, and then with difficulty. To obtain it pure, it ſhould be afterwards diſſolved in nitrous acid, and precipitated by aerated ſixed alkali, which is effected by virtue of a double elective attraction, for it cannot be diſlodged by cauſtic fixed alkali, (XIV.).

Ponderous earth forms, with moſt acids, ſalts of difficult ſolubility. From all, the ſmalleſt drop of vitriolic acid immediately throws down ponderous ſpar in the form of powder; wherefore I know nothing better than a ſolution of this earth, in acetous or marine acid, for detecting the fainteſt traces of vitriolic acid, for it takes it from every other baſis.

The acid of ſugar occupies the next place. If it be dropped into a ſaturated ſolution of ponderous earth, in the nitrous or marine acids, it ſeparates, in a few minutes, pellucid cryſtals, conſiſting of the earth combined with the acid that was added. The ſame acid decompoſes the compounds formed of terra ponderoſa, and the acids of amber, of fluor, phoſphorus, of the perlate, and that of ſugar of milk, which are all ſtronger than the marine acid.

The acid of amber comes into the third ſtation; that of fluor into the fourth, for it precipitates ſolutions made by acids of amber, fluor, ſorrel, phoſphorus, of perlate ſalt, nitre or ſea-ſalt; and leſt any one ſhould aſcribe this to the preſence of vitriolic acid, let it be obſerved that this ſediment, when collected and added to vitriolic acid, gives out fluor acid.

The acid of ſorrel expels the phoſphoric and perlate acids, that of ſugar of milk, nitre and ſea-ſalt, and forms a compound ſcarce ſoluble, which come next. The ſtrength of the ſebaceous acid has not yet been determined; in the mean time I have placed it after the marine. The remaining form this ſeries: acid of lemon, tartar, arſenic, ants, milk, benzoin, vinegar, of borax, of vitriol and nitre phlogiſticated, the aerial, and that of Pruſſian blue. The relative ſituation of the firſt mentioned individuals wants confirmation. Acid of arſenic does not viſibly render acetated ponderous earth turbid, but ſeems to form a triple compound; it, however, palpably expels the acid of benzoin.

I CONJECTURE, that, in the dry way, our earth comes next to the fixed alkalis; but I exclude the other earths, ſince the ponderous ſcarce fuſes with them. Beſides, I have ſubjoined fixed alkali, and calx of lead, ſince it enters into fuſion with theſe.

XLI.

Column Thirtieth, Lime.

Pure calcareous earth, or lime, in the ſtrict ſenſe of the word, is that which is free from every heterogeneous ſubſtance; but by this appellation I indicate the abſence of acids, eſpecially the aerial. Its attractions are very different from thoſe of ponderous earth. The firſt place belongs to acid of ſugar, which takes lime from every other, (Scheme 14.). To this ſucceeds acid of ſorrel, which decompoſes even gypſum, by attracting its baſis. Vitriolic acid exceeds the nitrous, and the others, (Scheme 16.). Acid of tartar takes lime from that of amber, the phoſphoric, perlate, and the following; and in like manner phoſphoric acid, the perlate, and that of ſugar of milk, from the nitrous, marine, fluor, arſenical, of ants, milk, lemon, and vinegar. Fluor acid attracts lime more powerfully than that of ants and vinegar ; but is ſcarce ſuperior to the nitrous and marine, unleſs by the aid of water, and a double attraction. Acids of lemon and benzoin exceed vinegar. The arſenical acid does not diſturb formicated and acetated lime, unleſs the ſolution be concentrated. The place of the ſebaceous is ſtill uncertain. The laſt individuals follow the order of the preceding column.

WHAT is ſaid in the preceding paragraph may be applied to the attractions of lime, magneſia, and clay, in the dry way, except that the laſt ſcarce attacks ſulphur.

XLII.

Column Thirty-firſt, Cauſtic Magneſia.

THIS ſalt, which is called in the ſhops *magneſia alba*, differs in various reſpects from lime, as I have ſhewn in a particular eſſay. I once thought, that this earth attracted acid of fluor moſt forcibly, and that all others were expelled by it, (Scheme 15.); but the repetition of the experiments gives room to ſuppoſe that I was miſled by the ſiliceous ſediment: I therefore aſſign the firſt place to acid of ſugar, and ſo on as in the column; of which the order is for the moſt part eſtabliſhed by experiments, in the diſſertation above mentioned. Some places are, however, uncertain, eſpecially thoſe occupied by the acids of ſorrel and lemon. Calcined magneſia is inſoluble in water, which is a great obſtacle when we are endeavouring to aſcertain attractions.

XLIII.

Column Thirty-ſecond, Pure Clay.

Under this denomination I underſtand earth of alum well purified, for common clay is always more or leſs mixed with the ſiliceous in powder: it contains, however, the real baſis of alum, and thence derives its peculiar properties.

The vitriolic acid attracts clay more powerfully than any other, next the nitrous, and then the marine acid. The order of the reſt is not ſufficiently aſcertained; it is, however, certain, that the acids of fluor, arſenic, ſugar, tartar, and phoſphorus, take clay from the acetous. The determination of the attractions is in this caſe prevented, not only by the inſolubility of pure clay, as in the caſe of magneſia, but likewiſe by the obſcure cryſtallization or deliqueſcence of the compounds, which commonly conceal the decompoſition.

XLIV.

Column Thirty-third, Siliceous Earth.

WHILST the vitriolic expels from fluor its proper acid, the ſurface of the water in the receiver, even in the gentleſt heat, is gradually covered with a white powder, which ſoon forms a cruſt. When this is broken, and ſinks, another is generated, and ſo on, as long as any acid of fluor paſſes over. This matter, when collected and waſhed, has all the properties of ſiliceous earth. I collected a parcel, and ſent it to Mr Macquer, who aſſured me that it had all the properties which ſiliceous earth ſhews in the focus of a burning glaſs. Now, whence comes this powder? Does it exiſt in the fluor, and is it volatilized by the heat? Or is it extracted from the glaſs? Or is it formed from its principles?

I BY no means deny, that fluor ſometimes contains ſiliceous particles, but they are accidentally preſent; for that of Garpenberg, which I generally uſed in this operation, ſometimes contains not a particle. This, when reduced to the fineſt powder, is totally ſoluble, by a long digeſtion, in aqua regia, which would never happen if it contained flint. Hence, therefore, it is evident, that ſiliceous earth enters the compoſition accidentally, and that the powder collected in the receiver is by no means to be aſcribed to it, ſince no ſuch ſubſtance exiſts in the compound. But perhaps other ſpecimens from Garpenberg are more or leſs mixed ed with it. Glaſs indeed abounds in ſiliceous earth, and is corroded during the proceſs; but as Mr Scheele ſaw the powder appear when metallic veſſels were uſed, I have long thought that in this experiment there was a generation of ſilex. Into a phial of iron or copper, upon which concentrated vitriolic does not act, there was put fluor mineral in powder, with an equal weight of ſtrong vitriolic acid; the cover was then applied, to which were faſtened below ſeveral different bodies, ſome dry, and others wet. The phial was expoſed for ſeveral hours to a gentle heat of digeſtion, and upon opening it all the moiſt ſubſtances were found to be covered with powder, and the dry ones quite free from it. But the fluor uſed in this caſe, without doubt, contained ſiliceous earth; for Mr Meyer has ſince found, by accurate and well conducted experiments, that no ſiliceous powder appears in metallic veſſels when no glaſs is uſed. The fluor with vitriolic acid yielded nothing; but the ſame mixture, in equal quantity, ſet in a metallic veſſel, when glaſs was added to it, ſwelled very much, and a ſiliceous powder was volatilized. The fluor acid, therefore, when reſolved into vapour, ſeizes ſiliceous earth with violence, extracts and retains it till it is abſorbed by water; for upon entering into this new combination, it is forced to depoſit part of the ſilex: the reſt remains diſſolved in the acid liquor, and may be thrown down by alkaline ſalts *. But no other acid is capable of diſſolving ſiliceous earth, not even in the very tender ſtate of a precipitate, from liquor ſilicum †.

Fixed alkalis, eſpecially when cauſtic, diſſolve very fine ſiliceous powder in the

---

* Opuſc. vol. ii. p. 34.

† *Ibid.* p. 36. and vol. iii. p. 314.

the moiſt way, but far more plentifully in the dry. All the acids, not even the aerial excepted, effect a ſeparation.

Liquor ſilicum is precipitated even by fluor acid; but the powder which falls does not conſiſt of pure ſiliceous earth, for it contains likewiſe fluorated alkali, and thus exhibits a triple ſalt.

Water entirely rejects ſilex in a moderate temperature. I always procure by evaporation a ſmall portion of ſiliceous earth from the water of the Upſal ſprings, notwithſtanding it has paſſed through the filter ſeveral times; but it without doubt is ſo fine, as when once mixed with the water, to be retained by friction; for diviſion increaſes the ſurface, and with it the friction, which at laſt becomes equivalent to the difference of ſpecific gravity.

In the dry way, ſiliceous earth is fuſible with borax, minium, and other proper ſubſtances, but moſt eaſily by fixed alkali.

Some of the moderns reckon *earth of ivory* among the ſimple earths, but improperly, for it is doubtleſs a compound, and, like earth of hartſhorn, contains both aerated and phoſphorated lime.

XLV.

Column Thirty-fourth, Water.

Since ſand in a very attenuated and volatile ſtate preſerves a level, ſo that animals may be drowned in it; ſince pounded gypſum ſet in a kettle over the fire ſeems liquid, not to mention other inſtances, why may not liquids in general be conſidered as ſolid molecules too ſubtile to be perceived by the ſight, however aſſiſted, and on account of their levity, bulk, figure, or by the interpoſition of another fluid, moveable with the greateſt eaſe, and affecting an horizontal ſurface? Hence water would ſeem to be nothing but earth kept liquid by heat. It certainly concretes into a ſolid body when the heat is diminiſhed to a determinate degree; but when the heat is increaſed to a certain term, it is reſolved into elaſtic vapours.

EVERY particle having a certain force of attraction for the principle of heat, forms a little atmoſphere for itſelf. As long as theſe atmoſpheres prevent the particles from coming into contact, the whole remains liquid; when they are enlarged, the diſtances increaſe, and an expanſion takes place, till at laſt the ſuperficial particles are reſolved, by the neceſſary quantity of heat, into elaſtic vapour. At 212° the whole maſs undergoes this change. The vapours then ariſe in great abundance, and produce the agitation of boiling. They exceed the bulk of the water 14,000 times, and then the vaſt ſurface is able to abſorb a far greater quantity of heat than before; and is it not thus that all evaporation produces cold? On the other hand, the exceſs of heat being gradually diminiſhed by the coolneſs of the air, or in any other way, the bulk of the vapours is contracted, and they are condenſed at laſt into drops of water. If the matter of heat goes on to decreaſe, the particles drawing near to contact loſe their reſpective mobility, and concrete into ice. What is hereafter to be ſaid on the ſubject of ſpecific heat, will farther illuſtrate theſe remarks, (XLVIII.).

SALINE, gummous, and ſpirituous ſubſtances are eſpecially ſoluble in water. In what order the ſalts are taken up, has been hitherto little examined, nor is this an eaſy taſk. Concentrated vitriolic acid takes water from a ſolution of vitriolated vegetable alkali, of alum, vitriol, corroſive ſublimate, and other ſubſtances, which it does not decompoſe, ſo that they cryſtallize almoſt inſtantaneouſly. The other acids ſcarce exert this power perceptibly.

Caustic alkalis likewiſe attract water ſtrongly, and precipitate various ſalts which they do not decompoſe.

Water attracts ſpirit of wine more forcibly than thoſe ſalts which are inſoluble in ſpirit of wine, and which therefore may be precipitated by it. This is the caſe with volatile alkali, which, when thus precipitated, is called *Van Helmont's ſoap, Sapo Helmontii.*

The elective power of water with reſpect to neutral and middle ſalts is hitherto unknown, and has been totally neglected. It is, however, probable, that each is attracted with unequal force, and that one gives way to another.

Æther may in ſome meaſure be ſeparated from ſpirit of wine by water.

XLVI.

Column Thirty-fifth, Vital Air.

A.] The atmoſphere which every where ſurrounds our globe, conſiſts of a pellucid, elaſtic, and apparently homogeneous fluid, which we denote by the name of *common* or *atmoſpheric* air: when more cloſely examined, it is found to contain, beſides vapours which vary wonderfully, according to the diverſity of ſituations and winds, three fluids mixed together, and widely differing in their nature. The greateſt part, which certainly exceeds the others three times or more in bulk, is neither fit for ſupporting fire, nor for reſpiration, probably derives its origin from the vital part, in conſequence of ſome change not yet certainly known, perhaps proceeding from the addition or ſubtraction of phlogiſton, and may therefore be called *corrupted* air. That which in England is called *dephlogiſticated*, and which I have formerly termed uncombined, good or pure, but now think with the hiſtorian of the Pariſian Academy, that it ſhould be diſtinguiſhed by the appellation of *vital;* this, I ſay, differs widely from the preceding, being not only fit, but indiſpenſably neceſſary for fire and reſpiration, every other air being mephitic. The aerial acid forms the ſmalleſt part of the atmoſphere, ſcarce ever amounting to one-ſixteenth.

B.] Vital air is found but ſparingly mixed with the atmoſphere, amounting ſcarce to one-fourth of its bulk, ſeldom or never exceeding one-third, as I have juſt intimated. It may, however, be obtained by various means. An ounce of nitre, expoſed to heat in a pneumatic apparatus, affords 500—600 cubic inches of air, far better, eſpecially at firſt, than common air. Nitrous acid poured upon many metals and earths, and then abſtracted to dryneſs, yields firſt nitrous air, if any phlogiſton be preſent, and then more or leſs of vital air. Vitriol of iron, copper, and zinc, and various vitriolated earths, nay, lapis calaminaris, manganeſe, and the calces of the noble metals acquired by precipitation, afford, when expoſed to a due degree of heat, a portion of vital air during their reduction. Hence it may be juſtly concluded, that this air can indeed be obtained without nitrous acid, but that by means of it a much larger quantity is procured, ſo that it is ſcarce to be doubted but that it enters as a principle into the acid, or the acid into it. In the former ſuppoſition, ſomething muſt be removed, which when again added to the vital air in proper quantity, muſt impart to it, beſides other properties, a ſtrong acidity. The nature of this is unknown. Nitrous air alone is at leaſt inſufficient, unleſs the exiſtence of phlogiſton be denied, which, however, would be contrary to evident experiments; nor does it ſeem to be the inflammable principle, by which, on other occaſions, all the acids are debilitated, and, when fully ſaturated, are as it were fettered. It ſhould, however, be remembered, that compounds ſometimes have properties not belonging to either of the ingredients. But in the caſe in queſtion, this bare poſſibility is unſupported by any experiment, which ſhews that diſtinct acidity proceeds from phlogiſton. The latter propoſition is countenanced by the following conſiderations. It appears from experiment, that nitrous acid very forcibly attracts phlogiſton, is rendered much weaker by it, and at length, by the aid of a certain portion of the matter of heat, acquires an aerial form, being changed into the aeriform nitrous acid: with a greater portion of phlogiſton, nitrous air is formed, containing the acid ſaturated; may not, therefore, a farther addition of phlogiſton or ſpecific fire, as the increaſe of weight ſeems to indicate, or both theſe cauſes, produce a new variation, and may not this be vital air? This opinion is, however, liable to difficulties, which ſhall be mentioned in the ſequel. Meanwhile, granting theſe poſitions, and aſſuming Mr Scheele's hypotheſis, the phænomena accompanying its generation admit of a conſiſtent explanation. We know that the acid as preſent in nitre may be phlogiſticated by fuſion. The coheſion is diminiſhed in proportion to the increaſe of phlogiſton, and by a certain quantity is totally deſtroyed, ſo that it is changed into vital air, and may be expelled by heat. The acceſſion of phlogiſton is derived from the decompoſition of heat; now, by the ſeparation of one principle, the other which is left uncombined, according to the hypotheſis, is vital air, and which therefore comes from two ſources, compoſition and decompoſition. If theſe things be true, we can eaſily comprehend how it is obtained from nitrous acid, poured upon almoſt any ſubſtance; and alſo how we come to procure a new portion, by adding freſh nitrous acid, when the former portion has been exhauſted. So great is the volatility of this acid, that it eſcapes before it is ſufficiently concentrated to receive phlogiſton; the baſis fixes the acid, and when it contains phlogiſton, contributes, at the beginning of the proceſs, while the heat is moderate, to the production of nitrous air.

THE ſubſtances which furniſh vital air without nitrous acid, contain, for the moſt part, ſome metallic principle, which, when acted upon by a ſtrong fire, decompoſes either their inherent ſpecific heat, or that which flows in through the veſſels. The noble calces ſeem by theſe means to be reduced to a metallic form, without the addition of phlogiſton, even ſuch as neither receive any aerial acid, nor contain any nitrous air, as gold diſſolved in dephlogiſticated muriatic acid, and afterwards precipitated. The ignoble calces of lead, iron, zinc, mangancſe, and perhaps others, are alſo capable of decompoſing heat, but cannot retain a quantity ſufficient for their reduction. Manganeſe does not indeed grow black from the action of heat alone; but by the aſſiſtance of vitriolic acid, it fixes a quantity ſufficient to render it ſoluble. Such phænomena ſometimes, though rarely, occur in the humid way. Upon minium dephlogiſticated, by a long continued calcination, and put into a ſmall retort, let a little more than its bulk of concentrated vitriolic acid be poured; the mixture ſoon grows warm, and acquires a black colour, a phænomenon which is produced by heat alone; then ſome degree of efferveſcence takes place, during which, ſome aerial acid is extricated; but in a minute or two the heat becomes inſupportable to the touch, and at the ſame time there iſſues out with vehemence a white ſmoke, which yields pure vital air: the volatilization of the powder gives it at firſt the appearance of ſmoke. The addition of pulverized glaſs renders minium more penetrable to the vitriolic acid; without this addition, the upper ſtratum of the maſs grows white, while the lower ſtrata ſtill remain black, or are not yet acted upon by the acid; in which caſe, aerial acid is extricated during the whole time of the production of any elaſtic fluid. I have treated minium in like manner with the muriatic acid; but in this operation the menſtruum muſt be made to boil. Then aerial acid is extricated, as alſo dephlogiſticated marine acid, and the vital air ſcarcely amounts to one-fourth. I have no doubt of the exiſtence of aerial acid in the minium; but it remains to be tried, whether it be preſent in minium recently prepared. I cannot determine this, ſince it is not made in Sweden. It probably does not unite with the lead during calcination, but is afterwards attracted from the atmoſphere, as happens with regard to lime. But the origin of the vital air is an important enquiry. Some deduce it from the dephlogiſtication of the aerial acid; Mr Scheele from the decompoſition of heat. All minium, hitherto examined, contains a ſmall portion of magneſia nigra, which is capable of decompoſing the matter of heat, and lead may perhaps have the ſame power. Muriatic acid is more eaſily decompoſed; and therefore, by employing this menſtruum, we gain but little vital air. Aerated lead, treated in the ſame manner, yields only aerial acid; but nitrated mercury, calcined to redneſs, and the ſpontaneous ſediment of vitriolated iron, when treated with vitriolic acid, produce nearly the ſame effects as minium. Iron is ſcarce ever without manganeſe, and ſeems itſelf capable of decompoſing heat; for that which is not magnetic, acquires this property in the crucible without any addition of phlogiſton.

The great ſpecific heat of vital air, which can be ſhewn by proper experiments, renders its origin from nitrous acid, by the addition of phlogiſton, not a little ſuſpicious; and perhaps future experiments will ſhew that it is not the real one.

C.] The relation of vital air to other bodies is now to be conſidered. There is no ſubſtance hitherto known, on which vital air acts more readily and efficaciouſly, than on nitrous air. At the inſtant of contact, the whole maſs almoſt hiſſes, turns red, grows warm, and contracts in bulk. The enquirers into nature are not yet agreed about the cauſe of theſe phænomena. There are two prevailing opinions, of which one will probably prove true. Mr Kirwan has thus explained it *. Phlogiſton is more ſtrongly attracted by vital air than by nitrous acid; wherefore the nitrous air is dephlogiſticated, loſes its nature, and the red vapour of nitrous acid is produced, which water readily abſorbs. But vital air, ſaturated with phlogiſton, forms aerial acid, and

---

* Phil. Tranſ. 1782.

and with a ſtill larger portion is converted into corrupted air. The bulk is ſometimes diminiſhed to $\frac{3}{100}$, in conſequence of the deſtruction of the nitrous air, and the generation of aerial acid, which being heavier than the vital air, and having leſs ſpecific heat, ought neceſſarily be contracted, and, moreover, may be totally abſorbed by water. The incaleſcence is produced by the deſtruction of the nitrous air, which, as well as the phlogiſticated vital air, parts with a portion of ſpecific heat. This is a very ingenious explanation; but before it can be received as quite ſatisfactory, ſo much aerial acid, as it ſuppoſes, muſt be more preciſely demonſtrated. If I miſtake not, the production of aerial acid is deduced from the precipitation of lime-water, and its quantity from the diminution of bulk. With reſpect to the former concluſion, it is well known that lime-water is manifeſtly rendered turbid by a very ſmall quantity of aerial acid, accidentally mixed with vital air; but the diminution, if it be repeatedly paſſed through recent lime-water, may ariſe from another cauſe, for water abſorbs one-fourteenth of its own bulk of vital air; if, therefore, a ſufficient quantity of water be preſent, the whole diminution may happen in this manner. In Mr Scheele's hypotheſis, the relation of vital to nitrous air is alſo made to conſiſt in the dephlogiſtication of the former; but it is ſaid, that the matter of heat is generated by this combination, which, in the preſent caſe, is not abſorbed by any of the ſurrounding bodies; for the nitrous air changing from fluidity to a liquid ſtate, muſt give out a portion of ſpecific heat, to be diſtributed among the contiguous ſubſtances, and evidently paſſing through glaſs. On what foundation this origin of heat reſts, I ſhall hereafter examine, (XLVIII.).

THE inflammable air of metals contains phlogiſton almoſt pure, in an aerial form; yet it neither changes vital air, nor is changed by it, not even when the ſurface of contact is increaſed by the acceſſion of external heat; a circumſtance which ſeems ill to agree with what has been juſt ſaid of nitrous air. But it is to be obſerved, that the decompoſition of nitrous air is the effect of a double attraction; the phlogiſton is attracted by vital air, and the acid part by water. Therefore, when the mixture is made in a phial immerſed in mercury, the experiment fails. But the contact of flame, or a glowing body, produces a wonderful effect in the mixture of inflammable with vital air; for it takes fire with ſo much violence, as far to exceed common fire in heat and efficacy, and to dazzle the eyes with the brightneſs of the light. If the conflagration be performed in a ſpace cloſed by mercury, as may be done by prudent management, the whole bulk of air is found to have in great meaſure diſappeared after the extinction of the flame, and the cooling of the apparatus. The reſiduum affords corrupted air, ſcarce ever mixed with aerial acid. This diminution is explained, as before, in two ways. It is impoſſible to deny, that a contraction of bulk muſt take place, if vital air be changed, by combination with phlogiſton, into aerial acid, which is heavier, and has leſs ſpecific heat; but the farther change of aerial acid by phlogiſton into corrupted air, a lighter ſubſtance, and therefore neceſſarily occupying a larger ſpace, ſeems ill to agree with the ſmall portion which remains after deflagration, though even the whole of the inflammable air ſhould become fixed.

If we ſuppoſe both airs perfectly pure, this inflammation would ſeem the moſt ſimple of all; for there is no ſuperfluous principle preſent, either to give out any extraneous fluid during the operation, or to yield any reſiduum which greedily abſorbs a portion of the mixture.

Electric ſparks ſeem to come neareſt to this operation; they may be conſidered as ſmall flames changing the vital air which they meet with on the ſurrounding medium, by means of their phlogiſton, either into aerial acid or heat, as muſt be determined by future experiments. Alkaline air is changed by the electrical ſpark into inflammable air of thrice its bulk, which ſufficiently ſhews that theſe ſparks give out phlogiſton in a free and elaſtic ſtate.

In vital air, without the aid of external heat, phoſphorus is conſumed very ſlowly, and ſcarce at all, unleſs water be preſent to forward the decompoſition, by a double attraction. It may be burned by proper management in a glaſs veſſel cloſed with mercury.

The method that beſt ſucceeded with me, was to introduce a ſmall piece into the glaſs veſſel, and ſet fire to it, by applying the flame of a candle externally. This was repeated as long as the bits ſucceſſively introduced could be made to deflagrate. After the apparatus had grown cool, there never remained above one-fourth, often not above one-tenth of air, and ſometimes ſtill leſs; the reſiduum conſiſted of corrupted air, very ſeldom mixed with aerial acid. Here the hypotheſis, concerning the origin of the aerial acid and corrupted air, from the phlogiſtication of the vital, ſeems ſcarce admiſſible. We have in this experiment no uncombined phlogiſton, by conſolidation of which the bulk might be diminiſhed. The difficulty is, however, leſſened, by the abſorbing power of the uncombined phoſphoric acid, of which more will be ſaid hereafter. Sulphur may be burned in the ſame way, and exhibits almoſt the ſame phænomena.

THAT kind of inflammation is moſt complex, which conſumes a body that gives out aerial acid from its own ſubſtance, and at the ſame time yields an abſorbent reſiduum. To this head belongs the combuſtion of pyrophorus, candles, and other animal and vegetable ſubſtances. There can be no inflammation without vital air, whence it may be conſidered as the pabulum of fire; yet the phænomena vary according to the nature of the bodies to be conſumed. It is aſſerted, that in a ſpace limited by mercury, a candle which is left to burn as long as it can, diminiſhes the air little or none; and it is certain that the bulk is found the ſame after cooling, for the conſumed fat yields a quantity of fluid nearly equal to the vital air conſumed by the flame. It is known that oils, when decompoſed in cloſe veſſels by fire, gives out aerial acid.

Hepatic air, dephlogiſticated by vital, depoſits ſulphur but ſlowly; whereas nitrous air is decompoſed at the moment of contact.

Metals, being loaded with phlogiſton, cannot but be expoſed to the power of vital air. The ignoble ones are decompoſed more or leſs quickly, according to circumſtances; the noble reſiſt obſtinately: however, the pureſt gold, when fuſed, and ſufficiently rarefied by the focus of a lens, is forced to part with ſome of its phlogiſton *. Mercury, which ſeems intermediate between the noble and the ignoble, when ſufficiently heated, is well and quickly calcined in vital air, but remains unchanged in corrupted air, as Dr Prieſtley has found. I have experienced the ſame

---

* Macquer Dict. de Chimie.

ſame thing with that mixture of lead, tin, and biſmuth, which is fuſible in the heat of boiling water. The effects are here alſo explicable from the generation of aerial acid, or the matter of heat. On the former ſuppoſition, a difficulty ariſes from the rejection of aerial acid by many metallic calces, and from the reduction of gold without addition, when it has been diſſolved in dephlogiſticated marine acid, and precipitated by alkali, when the calx is neither contaminated with aerial acid nor nitrous air. By Mr Scheele's ſyſtem, theſe difficulties are avoided, but others occur not eaſily to be obviated by the decompoſition of heat. The calcination of lead by mercury in common air *, which is diminiſhed one-fourth, and yields an aerated calx, is among them; for I have never found in common air a quantity of aerial acid amounting to one-fourth of common air, nor, I believe,

---

* Mr Kirwan.

lieve, has any one elſe: it remains, however, to be tried, whether the bulk of the aerial acid, when expelled, correſponds to the above-mentioned diminution. The increaſe of weight is aſcribed, with great probability, to aerial acid, when it is preſent; but I can ſcarce doubt that ſomething is contributed by the increaſe of ſpecific heat. Nor is the abſorption of moiſture by a ſpongy maſs, like that in queſtion, always to be neglected.

BESIDES theſe ſubſtances, many more are undoubtedly changed by the action of vital air, eſpecially thoſe containing phlogiſton; but the mode is unknown.

XLVII.

Column Thirty-ſixth, Phlogiſton.

THIS very ſubtile matter admits, like the aerial acid, of two ſtates, a ſtate of combination, and freedom. In the former, it enters into the ſtructure of bodies, eludes all our ſenſes, and can only be recogniſed by its effects, for which reaſon ſome have ſuppoſed it to be a fictitious ſubſtance, and totally impalpable, but without juſt reaſon. The two celebrated philoſophers, Prieſtley and Kirwan, have clearly proved its exiſtence, both analytically and ſynthetically, ſo that I think all reaſons for doubting are now removed. This principle, when in combination, and then it is properly called phlogiſton, may be ſet looſe by various methods; having recovered its elaſticity, and gained an aerial form, by a proper increaſe of ſpecific heat, it receives the name of inflammable air. In the next paragraph, we ſhall find data from the analyſis of charcoal for eſtimating the weight of phlogiſton in inflammable air; a cubic decimal inch of inflammable air is equal in weight to $\frac{63}{1000}$ of an aſſay pound, and it contains as much phlogiſton as two pounds of forged iron, *i. e.* $\frac{5}{100}$ *; therefore $\frac{63-50}{1000}=\frac{13}{1000}$ give the weight of ſpecific fire neceſſary to the aerial form, of which more will be ſaid in the next paragraph, (XLVIII. C. E.). I ſpeak here only of the inflammable air of metals: that which organic bodies yield, appears to be leſs pure, and eſpecially combined intimately with a portion of aerial acid.

Phlogiston is perhaps to be found in all bodies, though in many it is concealed by its exility. The attractions of the more remarkable combinations into which it enters can alone be examined here; a taſk which is incumbered by no trivial obſtacles. Magneſia nigra, for inſtance, attracts it with ſuch violence as to decompoſe acid of ſalt. It takes this principle from all the metals, but not without the aid of ſome acid; a circumſtance to be carefully noted. Nor does it act with ſo great force, till it has obtained the quantity neceſſary to perfect ſaturation, but only till it has acquired that which is neceſſary to its ſolubility in acids. When this point has been once attained, the complement which effects complete reduction is attracted more feebly than by any other metallic calx. An attraction of this kind, ſtopping at a certain point, takes place in many other metals, though it has hitherto been little examined. Thus, calx of iron, and perhaps of the other ignoble metals, by expoſure to heat, acquires phlogiſton enough to become magnetic, but cannot acquire enough for reduction. In general, the reducing portion of phlogiſton adheres much more weakly than the coagulating. Theſe attractions are in ſome meaſure analogous to thoſe which acid of tartar exerts upon ſalts containing vegetable alkali, (XXXVII.). When the doctrine of affinities is brought to perfection, I foreſee that it will often be neceſſary to adduce the ſame ſubſtance in two or more different ſtates. Here the black and white calx of manganeſe may be introduced ſeparately; but the former does not act by its ſingle power, for it requires to be aſſiſted by an acid. That, therefore, which is placed in this column is the white.

---

* Analyſis Ferri, p. 24.

A PLACE can ſcarce be allotted to vital air, as it has ſcarce any effect, unleſs it be aſſiſted by a double affinity, or a great degree of heat. We have before ſpoken of its action on nitrous acid. Either external heat, or ſurrounding moiſture, is neceſſary to the complete decompoſition of phoſphorus.

Calcined mercury is reduced by digeſtion in acid of ſalt; but the cauſe has not yet been ſufficiently explored. As this acid, when dephlogiſticated, attacks the metal itſelf, the calx can ſcarce dephlogiſticate the acid. It remains, therefore, to be examined, whether dephlogiſticated air is produced during digeſtion. According to Mr Scheele's hypotheſis, the decompoſition of heat is ſufficient.

Volatile alkali is dephlogiſticated by magneſia nigra; but the cauſe is complex, depending upon nitrous acid.

Therefore theſe phænomena are at preſent of no uſe in determining the elective attractions; but the following are more ſimple, and ſeem adapted to this end.

NITROUS acid decompoſes ſulphur, very ſlowly indeed without boiling; but it ſeparates the principles of muriatic acid in a middle temperature.

DEPHLOGISTICATED marine acid does not act upon ſulphur; but it gradually decompoſes white arſenic, and immediately reſolves phoſphorus into a white ſmoke.

THOUGH the precipitation of metallic ſolutions by complete metals is really the conſequence of a double attraction, yet a ſingle attraction would be ſufficient, could phlogiſton be ſupplied in a proper ſtate. The inflammable principle has a different attraction for different calces, and combines with them to ſaturation; after which, the metals fall down in a complete ſtate, and cannot be rediſſolved, unleſs the exceſs of phlogiſton be removed. When any other metal whatever is put into a ſolution of gold, the gold is immediately precipitated, not on account of the inferior attraction of the acid, as it has hitherto been univerſally explained, but becauſe phlogiſton more readily unites with the calx of gold, than with the calx of the added metal. That this is the true cauſe, may be ſhewn both by the dry and humid way. With reſpect to the latter, a fine diſcovery, made by Mr Sage, throws great light on the queſtion. He puts into a diluted ſolution of a metal a piece of phoſphorus, which yields its phlogiſton to the metallic calx, and in ſome caſes completely reduces it. The calces of the noble metals, and of copper, thus recover their metallic ſtate*. Though there is here no reciprocal exchange of principles, yet two powers effect

---

* Rozier, Journal de Phyſique, 1781.

effect the decompoſition. Water alone gradually extracts the acid part of phoſphorus, but very ſlowly, and thus renders the combination of the metallic calx with phlogiſton more eaſy. We have experiments yet more direct. A ſolution of acid of arſenic in water is made to acquire a reguline form, by paſſing a ſtream of inflammable air through it, as Mr Pelletier atteſts *. The ſame thing happens to ſome other metallic ſolutions. Metallic calces may be reduced by the flame of pure inflammable air; which alſo happens if they are immerſed in this air in cloſe veſſels, and expoſed to the focus of a burning glaſs, as Dr Prieſtley has found. The air is diminiſhed in this operation; but the reſiduum retains its former nature, and is juſt as fit for contributing to reduction as before. Beſides, it is well known, that ſome metallic calces may be reduced by

---

* Journal de Phyſique, 1782.

by fuſion, with the addition of iron or any other proper metal.

The phænomena, therefore, which come under this head, when deduced from their real cauſe, totally invert the ſeries of metallic calces laid down in former tables. Thus, gold riſes from the laſt place to the firſt or ſecond, and zinc is reduced to the loweſt. This holds with reſpect to the reſt, as appears in the table of attractions.

It is certain that the arſenical acid attracts the inflammable principle with greater force than the phoſphoric; for if phoſphorus be put into arſenical acid, the ſurface ſoon grows black in conſequence of reduction.

In the dry way, I have placed the metallic calces according to the order juſt eſtabliſhed. I have placed the acid of arſenic before the calx of ſilver; for this acid expoſed to the action of fire with ſilver, diſſolves a portion of it, which cannot be done without dephlogiſtication. The dephlogiſticating portion is ſublimed in the form of white arſenic; the other immediately diſſolves the calx.

Supposing the matter of heat to conſiſt of phlogiſton and vital air, the place of vital air is between the calx of mercury, which is reduced as well as the noble calces, and the ignoble calces. It cannot, however, be denied, but that theſe alſo are capable of decompoſing part of the heat, though not ſo as to effect a complete reduction.

XLVIII.

Column Thirty-ſeventh, the Matter of Heat.

A.] The nature of fire exerciſed the genius of philoſophers in the earlieſt times, nor has the diverſity of opinion yet been reconciled. Nay, it has been made a queſtion, *Whether the phænomena which are aſcribed to fire are to be deduced from a peculiar matter?* Or, *Whether they depend only on the motion of the particles of bodies?* Now ſince all motion, which is excited on our globe, meets with reſiſtance, and, therefore, when left to itſelf, is progreſſively diminiſhed, as every day's experience teſtifies, it is not eaſy to conceive how the motion excited by the production of a ſpark, which muſt meet with continual retardation, ſhould nevertheleſs ſometimes acquire ſuch augmentation as to be able to conſume a houſe, nay, a whole city. Here the effect far exceeds the cauſe. But in this age, almoſt all philoſophers agree, that there is a peculiar matter of fire, which has gravity; exerts an attractive power; poſſeſſes other peculiar properties very palpable in various caſes, and capable of being accurately determined. I therefore think it ſuperfluous to dwell any longer upon the proof of this poſition. The nature of this matter is a point much more difficult to be determined, and affords a fine field for the exertion of the greateſt abilities. I think there can be no doubt that it ought to be called the matter of heat rather than of fire. Fire is the action of heat when increaſed to a certain degree, and, therefore, ſoon paſſes away after the conſumption of the fuel; but the heat continues though it becomes rarefied, and is diſtributed among other bodies. There is always heat in fire; but all heat is not ſufficient for exciting fire: a determinate accumulation is required in every caſe.

Unless, therefore, we ſhould chuſe to invert the uſual mode of ſpeaking, the denomination which I have placed at the head of the paragraph ſeems more ſuitable to the nature of the thing.

B.] The chief opinions now prevailing concerning the matter of heat may be referred to three ſyſtems.

Firſt, Some conſider light itſelf as elementary fire, which every where ſurrounds our planet, in an uncombined ſtate, becoming lucid when in ſufficient motion, and occaſioning different temperatures by its unequal denſity, highly elaſtic, light, ſubtile, and penetrating. Notwithſtanding its wonderful tenuity and mobility, it may be fixed in bodies, and enter into their compoſition as a proximate principle; in which ſtate it is denominated phlogiſton. The great ſimplicity of this hypotheſis recommends it; but it can ſcarce maintain its ground, ſince it has been ſhewn that uncombined phlogiſton is nothing but inflammable air, (XLVII.). Light ſeems moreover to be inferior in tenuity to heat.

Secondly, Others argue, that elementary fire, which in a ſtate of liberty occaſions warmth, is not only different from phlogiſton, but ſo oppoſite that one every where expels the other, at leaſt in part. Air during phlogiſtication gives out much ſpecific fire, which, when free, heats, calcines, cauſes ignition, &c. It is proved, that the very attenuated matter of heat is not equally diſtributed, and in proportion to the bulk of bodies, as Boerhaave affirmed, but that each body, by a peculiar attraction depending upon its nature, acquires a greater or leſs quantity. If the heat marked by the thermometer is increaſed or diminiſhed in a place where there are ſeveral bodies of the ſame weight, it is diſtributed among them in proportion to their powers; and in like manner, in reſtoring the equilibrium which is diſturbed by a diminution, they exonerate themſelves in proportion to their powers. A body abſorbs more heat in becoming liquid than it contains when ſolid; and there is need of a ſtill greater portion to induce the ſtate of vapour. Animals grow warm by reſpiration, *&c.* not to mention other phænomena which will be related below.

Part of the ſyſtem concerning the increaſe of latent or combined heat, when a ſolid becomes liquid, or a liquid is converted into a fluid, owes its riſe to the illuſtrious Black. It has ſince been cultivated with ſo much ſucceſs,

ceſs, both in England and Sweden, that it now ſeems to reſt on a ſure foundation *. The function of reſpiration has been particularly illuſtrated by Prieſtley and Crawford.

The *third* ſyſtem is that of my ſagacious friend Mr Scheele, who thinks that the matter of heat is not ſimple, but compounded of phlogiſton and vital air, cloſely combined, and that light conſiſts of the matter of heat, with an exceſs of phlogiſton. His Treatiſe on Air and Fire will beſt ſhew how he arrived at theſe concluſions. This hypotheſis is not without its difficulties, which I every where mention; it however ſeems to agree better with experiment than any other, and therefore I have often adapted my explanations to it. It is by no means neceſſary in this hypotheſis, that the contraction of the bulk of the air ſhould always be aſcribed to the heat paſſing through the glaſs. There is no reaſon why it may not be abſorbed on particular occaſions.

---

* See Crawford on Animal Heat, Magellan du Feu Elementaire, and Wilcke, in the Stockholm Tranſactions of 1773,—1781.

C.] I acknowledge that the new doctrine concerning the diſtribution of heat is well eſtabliſhed in many reſpects; but as it is connected with attractions, it will be proper to explain with greater accuracy in what light I view it.

LET the heat which we can meaſure by the thermometer be called *ſenſible*, and that which is ſo fixed by the attraction of bodies, that it cannot be indicated by the thermometer, *ſpecific*. For the ſake of compariſon, the ſpecific heat of water is expreſſed by unity, to which the ſpecific heat of other bodies of equal weight, and the ſame ſenſible temperature, is referred and expreſſed in numbers *, which indicate the proportion, but not the quantities. Let us ſuppoſe two bodies, *A* and *B*, of the ſame weight, whoſe ſpecific heats are as *a* to *b*; let the ſenſible heat in the vicinity of the bodies be increaſed by the quantity *m*, which is to be divided between *A* and *B*, the former will receive an increaſe $= \frac{a}{a+b}m$, and the latter $= \frac{b}{a+b}m$, ſo that $\frac{a}{a+b}m : \frac{b}{a+b}m :: a : b :: a + \frac{a}{a+b}m \quad b + \frac{b}{a+b}m$. This is alſo the caſe if *m* be ſuppoſed to be negative, or to denote a diminution, for in either caſe ſuch a diſtribution will take place, that the proportions of fixed heat ſhall remain the ſame.

---

* See Mr Magellan, who has given this theory an elegant mathematical form. The method of determining the ſpecific heats differs from that of Wilcke, but the events agree; a circumſtance which not a little confirms the truth of the doctrine.

But the ſpecific heats do not follow the proportions of ſpecific gravity, nor of bulk, but, if I miſtake not, the compound ratio of the peculiar attraction, and the ſurfaces. I do not mean the mere external ſurface, but the internal likewiſe: it is well known that there is no body perfectly ſolid, nay, gold itſelf, the heavieſt of all ſubſtances hitherto known, is perforated with inviſible pores to the amount of one-half of its bulk, as has been rationally conjectured by Newton. Hence we may form ſome judgment of the vacuities of other bodies, ſince they may be at leaſt relatively determined by their ſpecific gravity; but this aſſiſtance is of no uſe in the preſent caſe. Though every other figure affords a larger ſurface, yet let us aſſume ſpherical pores for the ſake of ſimplicity, and the vacuity of any body reduced to a ſphere of the diameter 10, the internal ſurface will be as the ſquare, that is, as $10 \times 10 = 100$. Suppoſe now this vacant ſpace to be divided into ten equal ſpherules, of which let the diameter, to avoid fractions, be expreſſed by m, and the internal will be as $10\,m^2$. If it be divided into an hundred ſpherules, it will be as $100\,n^2$, and ſo we may go on as long as we pleaſe. Thus the internal ſurfaces increaſe as the ſize of the pores decreaſe, and, in the ſame proportion, the ſpecific heats, if I am not miſtaken. As the pores amount always to more than half the bulk, and in moſt inorganic bodies altogether elude the ſight, however aſſiſted, by their minuteneſs, the external ſurface may be neglected as infinitely ſmall, and this perhaps holds concerning the peculiar force of attraction. The internal ſtructure of bodies may indeed be truly compared to a ſponge, though the apertures cannot in general be perceived. Now heat penetrates into all the pores of bodies, and when fixed, ſurrounds the ſmalleſt atoms like an atmoſphere, and adheres to them, deprived of its power of exciting warmth. The thickneſs of this ſtratum is increaſed or diminiſhed according to circumſtances. The following are a few inſtances which ſeem to confirm my conjecture, for the nature of the thing forbids us to expect a rigorous demonſtration. The particles of water, in the ſtate of congelation, touching each other at a greater number of points, cohere in conſequence of their attraction. But if a ſufficient quantity of heat penetrates into ice, the particles are gradually ſeparated, regain their little atmoſphere, and recover their mobility. In a ſtronger heat the maſs is dilated by larger atmoſpheres ſurrounding the particles, and their tenuity cannot but be increaſed by them.

Laſtly, in the boiling temperature, every particle is ſo much dilated, as to occupy a ſpace 14,000 times greater, and ſuppoſing the form to be ſpherical, as is in ſome meaſure viſible, acquires a ſurface about 600 times more extenſive. By this expanſion, the contact and the attraction depending on it increaſes exceedingly, ſo that a remarkable degree of cold is produced in the contiguous bodies, by the quantity of heat neceſſary to ſaturation being collected and fixed.

My opinion is alſo illuſtrated by the following facts. Let a thermometer, with a void ſpace above the liquor, and with the top cloſe, be ſupended in the receiver of an air-pump; as ſoon as the air begins to be rarefied by the ſtrokes of the piſton, the liquor of the thermometer will ſink, as was firſt obſerved by Dr Cullen. The deſcent is owing to the dilatation of the glaſs, in conſequence of the removal of the external preſſure, for if the point be broken before ſuſpenſion, the level of the liquor will not be changed by the rarefaction of the air. A vacuum does not therefore of itſelf produce cold. But if the globe of the open thermometer be moiſtened, the liqour will deſcend on the rarefaction of the air. The cauſe is to be ſought in the ambient air, for its particles being expanded afford a ſpace wider, and better fitted for abſorbing heat eſpecially from the water on the ball, which repairs its loſs from the glaſs, and is converted into vapour; the glaſs attracts heat from the mercury, which therefore contracts, till the equilibrium be gradually reſtored from the neighbouring bodies. We have then three places filled of the column, at the top of which ſtands the matter of heat; the firſt is occupied by air, the ſecond by glaſs, and the third by the liquid metal. That vapours transfer heat to rarefied air, I conclude from their ſudden condenſation into drops. It is obvious, that evaporation is much forwarded, in this caſe, by the rarefaction of the air. The moiſture is diſſolved by the heat which flows out, and is, therefore, expanded into vapours that are viſible, and productive of cold, as is well known. The air, however, can ſcarce deprive the glaſs of its heat, without the expanſion of the water into vapour, for when rarefied, it acts very ſlowly on the dry globe of the thermometer; abundant moiſture acts more efficaciouſly than when it is in ſmall quantity; nay, in general, the more volatile is the liquor uſed, the lower does the mercury deſcend. Therefore vitriolic æther, highly rectified ſpirit of wine, cauſtic volatile alkali, water and eſſential oils, ſhould, it would ſeem, be placed in the ſeries after air.

I HAVE formerly ſhewn that heat is abſorbed during the ſolution of ſalts which acquire a far more extenſive ſurface, and that it is let looſe again by ſudden cryſtallization *. For the ſame reaſon, muriatic air eagerly attracts phlogiſton, (XVI.), not to mention other proofs of efficacy heightened by an increaſe of ſurface. Beyond the ſphere of contact there is ſcarce any attraction, and therefore the area is of more importance than the denſity. For if as much be fixed to a denſe, but ſmall, as to a rare but extenſive ſurface, the elaſticity of the matter to be fixed will be more or leſs reſtrained below the equilibrium prevailing in the contiguous bodies, but the attractive power can ſcarce ſuſtain ſuch compreſſion.

EVERY body has a determinate ſpecific heat, which, however, appears, from

---

* Opuſc. vol. i.

from experiment, to vary with the ſtate of the body. In the ſolid ſtate it contains leaſt, in the liquid more, and the fluid, in which there is the weakeſt coheſion, has the moſt ſpecific fire. Within the limits of the ſtate of ſolidity, no variation has as yet been obſerved, though without doubt the ſpecific heat ought gradually to increaſe, in proportion to the approximation to liquidity, and *vice verſa.* It can ſcarce be doubted that ſuch variations are perceptible in the ſtate of fluidity.

Does this ſtratum of ſpecific heat, which involves the ſmalleſt particles of a body, in any way affect the weight of the whole? Without doubt this ſubtile matter has gravity, and when it is ſo fixed to the body by attraction, as not to act upon the thermometer, it ought to cauſe an increaſe of weight. In ſolids, indeed, it conſtitutes but an infinitely ſmall augmentation, ſo that the weight cannot be obſerved without great difficulty; but in fluids, in which it abounds more, and bears a greater proportion to the weight of the whole, it ought not to elude the accuracy of our inſtruments. Some experiments of Mr Lavoiſier afford hopes that it may be actually determined *. That very accurate chemiſt burned ſulphur and phoſphorus incloſed in common air by means of mercury; and when the apparatus was grown cold, he found that the acids, when freed from their combination, twice or thrice exceeded the burned materials in weight. Now whence comes this increaſe? Let the table at the end of this paragraph be conſulted, and it will be found that the ſpecific heat of ſulphur, and concentrated vitriolic acid, is as 0, 183 : 0, 758, that is nearly as 1 : 4. But if we conſider, that the ſpecific heat of vitriolic acid increaſes along with the inherent water,

and

---

* Mem. de l'Acad. de Paris, 1777.

and that our uſual concentrations leave a conſiderable quantity of ſuperfluous water, we ſhall be obliged to own that the ſpecific heat of the vitriolic acid, deprived of all extraneous water, ought to be reduced to 3, and probably ſtill lower. Now Mr Lavoiſier affirms, that the increments of the acid reſidua exactly anſwer to the weight of the vital air loſt during the operation; whence, he juſtly concludes, that this air has been abſorbed by the acid. As the ſpecific heat of phoſphorus has not yet been determined, a like deduction cannot be made with reſpect to it. Meanwhile, theſe experiments, inſtituted with a very different view, ſeem not a little favourable to Mr Scheele's hypotheſis. When the vitriolic acid is ſet at liberty by the combuſtion of ſulphur, its ſpecific heat ought to be increaſed in the proportion of 3 : 1. This increaſe is found upon experiment to have taken place. At the ſame time, an equal weight of vital air is loſt, and is quickly abſorbed, together with that portion of phlogiſton, which, when combuſtion is otherwiſe performed, generates vitriolic air; for the acid in Mr Lavoiſier's experiments, was without ſmell. The like phænomena occur in the combuſtion of pyrophorus, as the ſame chemiſt has found. Does not then the matter of heat coincide with the combination of vital air and phlogiſton in the preſent caſe? It has not yet been proved, nor is it indeed probable, that the aerial acid is among the principles of the vitriolic; it does not emit pure air, when combined with pure alkalis, unleſs perhaps in conſequence of the decompoſition of heat, but a large quantity of uncombined heat is extricated. Moreover, I think this experiment ſhould be repeated, not only in mercury but in dry air, in order to try whether the vitriolic acid can be obtained dry. It is as yet doubtful, whether the liquid which we find, does not originate in part from extraneous moiſture. A very accurate weighing of the reſiduum likewiſe, without any foreign additaments, may perhaps ſerve to determine the abſolute weight of heat, which promiſes the illuſtration of many obſcurities. Laſtly, we ſee the prepoſterous manner in which the gravity of heat has been hitherto ſought; metals, the heavieſt of all bodies, have been uſed for this purpoſe, though they were of all others the moſt unfit.

The laſt ten years are remarkable, among other things, for the change of many ſubſtances into an aerial form. And it is certain, that the generation of elaſtic fluids is highly worthy of examination. The experiments which have been hitherto made, ſeem to indicate,

1. THAT the *ſubſtances liable to this change are the more ſimple,* eſpecially ſalts, both alkaline and acid. We have long known, that the vitriolic, nitrous, muriatic, fluor, and acetous acids, as well as all thoſe of vegetable and animal origin, as alſo the vegetable and volatile alkali, may be brought to the ſtate of air. Theſe, retaining their acid or alkaline nature, are readily abſorbed by water, and ought, therefore, to be collected in veſſels full of mercury. The aerial acid is as yet of obſcure origin. Moreover, ſulphur* may be reſolved into hepatic air; nay, ſiliceous earth, with all its fixity, may be made to aſſume the form of air †. Many more bodies will, doubtleſs, hereafter, be brought to the ſame ſtate. Gold itſelf may be converted into the form of vapour by means of fire; but

---

* Opuſc. vol. ii. pp. 340. 345.

† *Ibid.* vol. iii. p. 397.

whether it can put on that of air, cannot be determined *a priori.*

2. THAT *the principal cauſe of this transformation is to be ſought in the matter of heat,* which ſubtilizes ſubſtances, and gives them elaſticity, by looſening their particles. No elaſtic fluid is found without a large portion of ſpecific heat; nay, phlogiſton itſelf is reſolvable by theſe means into an elaſtic form. The matter of heat comes in ſome proceſſes, either from the fire itſelf, when, for inſtance, the aerial acid is expelled from chalk, inflammable air from iron by heat alone; or when it is extricated by the vitriolic acid, for in the new combination the acid cannot retain all its ſpecific heat; what is ſuperfluous is extricated, and either totally or in part abſorbed by the air that is generated. This will be well illuſtrated, if we take equal portions of water, and add to the firſt, cauſtic vegetable alkali, to the ſecond,

cond, aerated vegetable alkali, and to the third an equal weight of aerated volatile alkali; upon pouring in nitrous acid, a great degree of warmth will ariſe in the firſt, a moderate degree in the ſecond, and in the third one ſtill leſs conſiderable; nay cold, when the quantities are varied, is produced upon ſome occaſions. The reaſon is, becauſe, in the firſt caſe, the acid in uniting with the cauſtic alkali gives out its ſuperfluous heat without diminution; in the ſecond, the aerial acid abſorbs great part of it; and as, in the third caſe, more of this acid is extricated, more heat is abſorbed, inſomuch that the quantity ſet free being inſufficient, the deficiency is ſupplied from the water of the ſolution, and ſenſible cold is generated. On the other hand, in the combination of the aerial acid with cauſtic alkali, the heat neceſſary to maintain the aerial form is ſet looſe, and produces a degree of warmth correſponding to its quantity. The other elaſtic fluids ſhew the ſame thing; the contiguous bodies are cooled during their production, and heated when they are fixed.

3. PHLOGISTON appears *likewiſe to be neceſſary.* Thus the acids, as the vitriolic and the nitrous, which in a ſtate of purity contain no phlogiſton, are reſolved by warmth into elaſtic vapours, but are condenſed into drops on mere cooling; but, by the addition of phlogiſton, afford permanently elaſtic fluids: this ſubſtance is therefore to be conſidered as a bond, affixing the neceſſary quantity of heat. The ſame thing holds with reſpect to hepatic air, which cannot be obtained from ſulphur, without the addition of phlogiſton. But the acids which always contain phlogiſton, as the muriatic, that of fluor, thoſe procured from the vegetable and animal

kingdom, need nothing but heat to put on an aerial form.

4. Moreover, *the different quantity of phlogiſton occaſions a great change.* In nitrous air extricated from different metals, there is ſome variation; that which ſurrounds iron filings in a cloſe veſſel, is by degrees ſo much corrected that it not only does not extinguiſh flame, but even dilates it.

In this ſtate, it is called by ſome *dephlogiſticated*, with what propriety I can ſcarce perceive, ſince the filings are at the ſame time calcined, which clearly ſhews a loſs of phlogiſton. Beſides, this experiment ſeems to coincide with that hypotheſis which derives vital air from nitrous acid ſufficiently phlogiſticated. The electric ſpark taken in alkaline air, produces inflammable air, either by tranſmuting part of it, or, as it ſeems, by ſetting free the combined phlogiſton, and furniſhing the neceſſary ſpecific heat; for the bulk is much augmented. Other inſtances of variation ariſe from the diminution of phlogiſton: ſuch is that elaſtic fluid which is called *dephlogiſticated ſea ſalt.* To this head we may alſo refer that air which is procured from nitrated volatile alkali, digeſted with magneſia nigra, and which reſembles corrupted air. The power of magneſia nigra in dephlogiſticating other ſubſtances is well known. That which is generated by the exploſion of fulminating gold, in which ſome degree of dephlogiſtication certainly takes place, is of the ſame nature *.

ALTHOUGH the quantity of phlogiſton in various bodies ſhould decreaſe, as the ſpecific fire increaſes, I would be far from deducing from this circumſtance any mutual repulſion. The augmentations and diminutions compared together do not warrant ſuch a concluſion;

---

* Opuſc. vol. ii. pp. 161, 162.

ſion; and ſpirit of wine, a ſubſtance abounding in phlogiſton, has a greater quantity of ſpecific heat than water, not to mention other arguments.

BEFORE I leave the genealogy of aeriform fluids, I muſt explain what I mean by the phraſe *aerial form*. I underſtand by this term ſuch a ſubtilization of a body as renders it elaſtic, pellucid, inviſible, light and permanent in cold, though not capable of paſſing through the pores of glaſs. *Vapours* which conſtitute imperfect kinds of air, are condenſed by refrigeration. On the other hand, we have elaſtic fluids, which may be not improperly ſtyled *æthereal;* to ſuch, neither the pores of glaſs, nor of any other known body, are impenetrable. To theſe belong the matter of heat, and the magnetic fluid. The electrical fluid eaſily penetrates all bodies, except electrics *per ſe*. Moreover, light ſeems to be ſomething intermediate between aerial and æthereal ſubſtances; for it paſſes through the pores of glaſs, but not thoſe of metals and other opaque ſubſtances.

HENCE the neceſſity of determining the weight of the ſpecific heat, in the analyſis of aeriform fluids, plainly appears. With reſpect to inflammable air, I have before offered a ſketch; and I truſt that Mr Kirwan, who has ſo ſucceſsfully engaged in this taſk, will not neglect this important part, ſince the analyſis will be otherwiſe imperfect; and when it is once known, their nature and origin will be wonderfully illuſtrated.

HERE follows a table of ſpecific, as far as they have been hitherto inveſtigated. I thought it proper to diſpoſe them according to the three ſtates of ſolidity, liquidity, and fluidity. The ſpecific heat of water is denoted by unity. Water heated to 130 degrees melts an equal weight of ſnow; but the water thus brought to a liquid ſtate is at the point of congelation. It would certainly be worth while to weigh, with the utmoſt exactneſs, a piece of ice in a perfectly cloſe veſſel, and to repeat the operation after it was melted. The ſtopple muſt fit, in the moſt accurate manner, leſt any thing ſhould be loſt in conſequence of evaporation. This experiment has not yet, as far as I know, been performed with proper care and accuracy; it may, however, aſcertain, in ſome meaſure, the abſolute weight of a quantity of the principle of heat correſponding to 130 degrees.

SOLIDS.

	Spec. grav.	*Spec. heat.*
Aerated volatile alkali,		1,851
Swediſh glaſs, -	2,386	0,187
Flint glaſs, - -		0,174
Agate, - -	2,648	0,195
Ice, - -		0,900
Sulphur, - -		0,183
Gold, - -	19,040	0,050
Silver, - -	10,001	0,082
Mercury, - -	13,300	0,033
Lead, - -	11,456	0,042
Copper, - -	8,784	0,114
Iron, - -	7,876	0,126
Tin, - -	7,380	0,060
Biſmuth, - -	9,861	0,043
Antimony, - -	6,107	0,063
Braſs, - -	8,356	0,116
Calcined lead, -		0,068
Calcined iron, -		0,320
Calcined tin, -		0,096
A mixture of lead and tin calcined, -		0,102

	Spec. grav.	*Spec. heat.*
Diaphoretic antimony waſhed, -		0,220

L I Q U I D S.

	Spec. grav.	*Spec. heat.*
Pure water, - -	1,000	1,000
Clear vitriolic acid,	1,885	0,758
Dark coloured vitriolic acid, - -	1,872	0,429
Pale nitrous acid, -		0,844
Red and ſmoking,	1,355	0,576
Smoking muriatic acid,	1,122	0,680
Red wine vinegar, -		0,387
Concentrated diſtilled vinegar, - -		0,103
Alkali of tartar by deliqueſcence, -	1,346	0,759
Cauſtic volatile alkali,	0,997	0,708
Of vitriolated foſſil alkali 1 part, in of water p. 2. 9. -		0,728

	Spec. grav.	*Spec. heat.*
Of nitrated vegetable alkali, p. 8. - -		0,646
Of muriated foſſil alkali, p. 8. - -		0,832
Of muriated volatile alkali, p. 1. 5. -		0,798
Of depurated tartar, p. 237. 3. - -		0,765
Of vitriolated magneſia, p. 2. - -		0,844
Of vitriolated clay, p. 4. 45. - -		0,649
Of vitriolated iron, p. 2. 5.		0,734
Brown ſugar diſſolved,		1,086
Oil of olives, - -		0,710
—— linſeed, -		0,528
—— whale, (ſpermaceti)		0,399
—— turpentine, -		0,472
Rectified ſpirit of wine,	0,783	1,086
Volatile liver of ſulphur,	0,818	0,994

F L U I D S.

	Spec. grav.	*Spec. heat.*
Vital air, -	000,132	87,000
Atmoſpheric, -	000,125	18,000
Aerial acid, -	000,181	0,270

I HAVE been informed by Mr Kirwan, in a letter, that Dr Crawford found the ſpecific heat in equal bulks of inflammable and atmoſpheric air equal. Admitting this, if the ſpecies of air in Mr Kirwan's table, publiſhed by Mr Magellan, are eſtimated by weight, the ſpecific heat of inflammable air will be 281, which is more than triple of that of vital air.

D.] The theory of the diſtribution being now in ſome meaſure explained, it is proper to conſider the origin of fire in *inorganic* bodies, its propagation, and the conſequences.

Fire is ſuch an accumulation of heat that the bodies expoſed to it become ignited or inflamed. The chief means of exciting it are:

1. The ſtriking of flint or pyrites againſt ſteel, by which the abraded globules are ignited, fuſed and calcined.

2. The forging of iron, which is brought to ignition by repeated ſtrokes of the hammer.

3. The mixing of ſulphur and ſteel filings, which, with a proper degree of moiſture, grow warm, and burſt afterwards into flame.

4. Adding the ſmoking nitrous acid in a proper manner to oils.

5.

5. Pyrophorus grows red hot in atmoſpheric air, and produces flame in vital air *.

In all theſe caſes, there is no heat produced without vital air, which alſo, according to circumſtances, is more or leſs diminiſhed. Phlogiſton is likewiſe preſent in them all. The late Engliſh philoſophers contend, that the diſengaged phlogiſton unites with vital air, and forms aerial acid, or when in a larger proportion corrupted air, by which change, a great quantity of ſpecific heat is neceſſarily ſet looſe, and being accumulated, produces ignition, and even flame when inflammable air is preſent. Scheele contends, that vital air may be totally changed by phlogiſton into the matter of heat. Both

---

* Mr Kirwan has lately informed me by letter that there is a certain kind of earth found in Derbyſhire which takes fire in a ſhort time, on the addition of linſeed oil. I have not as yet ſeen this earth.

opinions are ſupported by ſtrong arguments. It is, therefore, of great importance, that the nature of the combination of phlogiſton and vital air ſhould be demonſtrated. Mr Kirwan thinks the aerial acid is the product; and by his ſagacity, has been able to render this opinion very probable: there is, however, ſtill room for ſome doubts; when theſe have been removed, the ſyſtem of Scheele will ſcarce be tenable. It is probable, that, in the two firſt caſes, a part of the ſpecific heat is expreſſed by the compreſſion of the pores, and accumulated when the dephlogiſticating temperature commences, and is afterwards increaſed by the ſurrounding air. The ignition or inflammation of inorganic bodies is propagated to others that are capable of it, by contact or vicinity. All bodies may be ignited; a few only can be inflamed; ſuch are ſulphur, phoſphorus, inflammable air, arſenic, zinc, and ſome others.

The conſequences of ignition or deflagration vary according to the diverſity of bodies, and the degrees of fire. The accumulation of heat cauſes expanſion, dries, liquefies, makes bodies red hot, expels ſuch as are volatile, indurates, inflames, volatilizes, calcines, vitrifies, reduces. The reſidua abſorb a quantity of heat ſuitable to their nature, as is very evident from pyrophorus, which deſtroys, during its ignition, nearly $\frac{3}{4}$ of atmoſpheric air, whereas other mediums ſcarce diminiſh it by $\frac{1}{5}$: in vital air it takes flame, and nearly $\frac{143}{144}$ diſappear *. The cauſe is to be ſought in the hepar which is contained in pyrophorus, and in the decompoſition of the ſulphur, in conſequence of which the vitriolic acid is laid bare, and muſt neceſſarily be furniſhed with its portion

---

* Lavoiſier, l. c.

portion of ſpecific heat [*]. Some reſidua are of an acid nature and deliqueſcent. Others are found in the form of calces, aſhes, ſaline or reſinous compounds.

E.] *Vegetables,* though they yield the greateſt quantity of combuſtible matter in our globe, and eaſily propagate fire once lighted, generate it themſelves but very ſlowly. To produce it by friction, there is required wood, hard, dry, and penetrated with much inflammable matter, and even, in theſe circumſtances, the operation is a trial of patience. It is ſaid, that fire has often ariſen from the accumulation of graſs not ſufficiently dried, but no one yet, as far as I know, has examined theſe phænomena with due care.

When dry wood is expoſed to fire, it grows warm and expands; the humidity, which is generally acid, is reſolved into vapour; the phlogiſton is diſpoſed to be driven off, and then is attracted, partly by the ſurrounding vital air, and is partly diſengaged with the requiſite ſpecific heat in the form of inflammable air, and, in the ſame inſtant, is ſet on fire and produces flame. Thus, the whole fabric of the wood is gradually deſtroyed, and, in the mean time, more or leſs ſmoke is emitted, by which the ſoot is depoſited. Fire cannot ſubſiſt without vital air. Hence, when it is lighted, an afflux of air in a continual ſtream takes place, which riſes loaded with phlogiſton, and rarefied by warmth, carrying along with it carbonaceous particles not ſufficiently burned; which particles are loaded with fixed vegetable as well as volatile alkali, and with earth and ſal ammoniac. I have aſſerted, that the particles not ſufficiently burned, generate ſoot; for the furnace, which has the name of ακάπνος, totally deſtroys the ſmoke which is brought through the fire-place.

---

[*] See the ſubdiviſion marked C.

When the inflammable air, and, of courſe, the flame fail, the conflagration is diminiſhed, and nothing but charcoal and aſhes remain. In a cloſe veſſel the charcoal amounts to one-fourth, ſeldom to one-fifth of the weight of the wood; but in the open air, great part of the charcoal is reſolved into aſhes. This is effected by a double attraction; the vital air ſolicits the phlogiſton, while the alkali and alkaline earth attract the aerial acid. In a cloſe veſſel charcoal reſiſts the moſt intenſe fire. This ſubſtance is nothing but a combination of phlogiſton and aerial acid, a ſpecies of ſulphur which is found intimately combined with cauſtic alkali and alkaline earth, and hence it approaches, in ſome meaſure, to the nature of hepar. By combuſtion in the open air, 100 parts of charcoal contain about 6 of aſhes; of theſe $\frac{1}{900}$ conſiſts of alkali, the reſt of earth, in great meaſure alkaline. I have particularly examined well burned charcoal made of the pinus ſylveſtris of Linnæus. Of this 1 part, during detonation, alkalizes 3 of nitre, hence the phlogiſton it contains, is, in compariſon of that contained in forged iron, as 3 to $\frac{1}{2}$ *. Upon 100 parts reduced to powder, I poured concentrated vitriolic acid, then diſtilled to dryneſs, and, in a pneumatic apparatus, collected about 82 cubic inches of aerial acid, of which each is equal in weight to a docimaſtic pound. If then we add 3, which nearly correſpond to 6, the parts of the aerated aſhes, there remain 15, which give the weight of phlogiſton. No veſtiges of vital air appear. The proportion of the principles varies according to the diverſity of the wood, age, exſiccation, and

---

* Analyſis ferri, pp. 51, 52.

and combuſtion. Meanwhile, it appears from preceding obſervations, that 1 part of phlogiſton can fix nearly $5\frac{1}{2}$ of aerial acid. The ſpecific heat of wood is a little greater than the ſpecific heat of charcoal, of equal weight.

Moreover charcoal has a peculiar attraction for elaſtic fluids. Ignited charcoal abſorbs, during refrigeration, about 6 times its own bulk of any kind of air. If the hot coal be cooled in quickſilver, or in a void ſpace, it nevertheleſs retains this power of abſorption, and, when immerſed in air, exerts it inſtantaneouſly, as the celebrated Fontana has obſerved. This air is expelled by water or any other liquid.

The parts of animals are, in like manner, conſumed and converted into charcoal, which, however, ſeems to abound more in phlogiſton, and to retain it more obſtinately. I have not yet attempted to analyſe it. Soot from animal ſubſtances generally abounds more in volatile alkali and ſal ammoniac, than that obtained from vegetables. The ſmell of the ſmoke is exceedingly offenſive.

F.] In animals with hot blood, we find a ſenſible temperature ſuperior to that of the atmoſphere, which is alſo conſtant and permanent, though the ſurrounding medium, from its greater coolneſs, ought to abſorb the difference, as happens in the caſe of other bodies. This phænomenon indicates a cauſe perpetually in action, which, in this age, has been ſought by many, but ſeems to have been moſt ſucceſſively inveſtigated by Dr Crawford. Many conſiderations tend to ſhew, that animal heat is generated in the lungs. The larger theſe are, the hotter are the animals. Hence birds exceed animals in this reſpect. Reſpiration is accelerated by a more violent motion than uſual, and the heat is at the ſame time increaſed, an effect to be aſcribed to the quantity of air reſpired, and by no means to friction in a body full of liquids. Animals without lungs have their temperature depending on that of the medium in which they live; to us they feel cold, not to adduce any more proofs of the efficacy of the air. But the manner in which the effect is produced, is connected with the preſent enquiry. Dr Prieſtley contends that common air ſerves to carry off the ſuperfluous phlogiſton of the body. Dr Crawford afterwards embraced this opinion, and has admirably illuſtrated the whole proceſs. Having not yet ſeen his pamphlet, I have borrowed my idea of his ſyſtem from Mr Magellan's eſſay. The ſpecific heat of common air is to that of aerial acid, as 69 : 1, ſo that if theſe two fluids were to receive an addition of heat of one degree, the former would fix 69 times more than the latter. Now we know, from the obſervations made at Peterſburgh, that the mercury may deſcend at leaſt 111 degrees of the Swediſh thermometer, below the mean temperature. Therefore, if the common air was to be changed into aerial acid, $69 \times 111 = 7659$ degrees of heat muſt be ſet free, *i. e.* 13 times more than is neceſſary to turn iron red hot. Now, as common air is phlogiſticated in the lungs, and converted into aerial acid, we may hence form ſome judgment of the quantity of heat, which is ſet free by reſpiration, and may ſerve to warm the body. Beſides, as the ſpecific heat of the arterial blood is to that of the venous, as 100 : 89, the author thinks it evident, that phlogiſton is gradually accumulated in the veins, and exonerated in the lungs, that the blood may be rendered capable of receiving the due ſpecific heat.

All this is pretty conſiſtent, and highly ingenious: but that all the fundamental parts of this theory, which are certainly not improbable, may be further illuſtrated by new experiments, I ſhall add a few remarks.

1. It remains to be aſcertained, whether animals or vegetables contain moſt phlogiſton. I know no experiment which decides this queſtion, and it ſeems indeed very difficult of ſolution, for the problem is, not concerning this or that particular part, but to compare the whole body of an animal with a vegetable of the ſame weight. If we conſider our food, conſiſting entirely of organiſed bodies, we ſhall find that they have been for ſome time dead, before they appear on our tables, often long before; and there can be no

doubt, but more or leſs of phlogiſton is extricated during the interval. Next the operations of cookery diſſipate a conſiderable quantity, nor can we be certain that this is compenſated by the ſauces. The flatulency that is expelled from the belly, is inflammable, and the ſolid excretions are well known to abound with phlogiſton. Beſides, a great quantity of phlogiſton ſeems to be requiſite for the purpoſes of the animal œconomy at all times, and in every part of the ſyſtem, and I confeſs that I know not whether that which is taken in with the ingeſta is ſufficient. Still leſs can I be certain that there is any ſuperfluity to be carried off.

2. EXPERIMENT ſhews a greater ſpecific heat in the arterial than the venous blood. Let us grant that the acceſſion of phlogiſton often leſſens the ſpecific fire, it by no means follows that

phlogiſton is the agent in the preſent caſe. We have other means of bringing about the ſame diminution. Thus the pureſt vitriolic acid, added to water, excites a great heat. The water combined with the acid cannot retain all its former ſpecific heat, wherefore the ſuperfluous part is ſet free, and that without the aid of phlogiſton. While the blood is circulating, various changes may diminiſh the ſpecific heat, which indeed ſeems neceſſary, that the parts at a diſtance from the heart, may continually receive ſome heat.

3. I KNOW no experiment which directly ſhews that the blood imparts phlogiſton to the air. The air is indeed corrupted, but that this can only be effected by phlogiſton, is a mere ſuppoſition. On the contrary, by the contact of blood, nitrous air is

dephlogiſticated, and atmoſpheric air is meliorated[*].

4. THAT the expired air contains a portion of aerial acid cannot be doubted, but I think that the quantity requires to be determined more accurately. If all that is good is converted into this acid, 1000 cubic inches of atmoſpheric air, of which one $\frac{1}{3}$ is vital, ought, according to the analyſis of Mr Kirwan, to be condenſed to the bulk of about 926, *i. e.* $\frac{1}{14}$ ſhould diſappear, and of vital air, 1000 ſhould be reduced by reſpiration to 863, *i. e.* they ſhould be diminiſhed by $\frac{1}{7}$, if they can be inhaled by the lungs till they are totally corrupted. Suppoſing that aerial acid is further changed into corrupted air, a ſmaller contraction may be expected.

BUT the doctrine concerning the origin of animal heat, is reducible to the

---

[*] Dr Prieſtley.

fundamental queſtion, concerning the change of vital air into aerial acid, and of this into corrupted air; an opinion which every day ſeems to receive confirmation. Mr Kirwan has lately communicated to me a new experiment of great importance, made by Dr Prieſtley; That calx of mercury, which is commonly called precipitate *per ſe*, and which, when expoſed to fire, yields pure vital air, afforded but $\frac{1}{6}$ of vital air on the addition of iron filings, and $\frac{5}{6}$ of aerial acid. If the filings had ſuffered no degree of calcination, this reſult ſeems to decide the queſtion. Meanwhile, I rejoice, that it is reduced to ſuch a ſtate, that we cannot long remain uncertain.

XLIX.

XLIX.

Column Thirty-eighth, Sulphur.

Sulphur prefers fixed alkalis to earths; on which account, hepar made with lime, and diſſolved in water, is decompoſed by alkali, and a ſaline hepar is formed. Between vegetable and mineral alkali no difference in this reſpect has yet been obſerved. The power likewiſe of ponderous earth has not been aſcertained; it probably yields to fixed alkali, for volatile alkali, both cauſtic and aerated, precipitates hepar made with lime, when diſſolved in a ſmall quantity of water, and ſeparates the calcareous earth. Let magneſia alba be put into a phial with flowers of ſulphur, and diſtilled water; let the phial be cloſely ſtopped, and then digeſted a few hours in a water bath; when it is afterwards cooled, it will yield a weak ſolution, emitting an hepatic ſmell, and turning black on the addition of nitrated ſilver, or acetated lead.

Volatile hepar, obtained from ſulphur diſtilled with ſal ammoniac and lime, is very ſoon decompoſed in the open air, ſince pure volatile alkali attracts the aerial acid in preference to ſulphur. That this alkali is ſuperior to earths, appears from what has been ſaid above. It is well known, that mercury and arſenic take ſulphur from it, for theſe metals, and even their calces, when added to the volatile hepar, are mineralized in the moiſt way; the former yielding cinnabar, and the latter red arſenic. It is probable, that this is true of other calcined metals. Hence it appears, that the calces of metals may be combined with ſulphur, a truth which ochre of iron ſhews clearly and directly; for by being mixed with ſulphur, it yields effloreſcent vitriol: the operation may be forwarded by moiſtening the mixture. It has been elſewhere ſhewn *, that calx of antimony can take up ſulphur. Nay, the calces of lead, tin, and ſilver, when added to ſaline hepar, ſeem to take ſulphur from vegetable alkali.

It now ſeems no longer doubtful, where the oils ſhould ſtand in columns 26 and 27; for I have obſerved, that a drop of oil, added to either ſaline or earthy hepar, produces white coagula, reſembling ſoap. This matter is alſo ſoluble in ſpirit of wine, and the oil may be precipitated from ſuch a ſolution by water. But it is as yet undetermined in what order ſulphur attracts the oils.

In the dry way, alkali occupies the firſt place; then follow the metals, of which the reſpective ſtation is to be aſcertained

---

* De antim. ſulphur. p. 177.

aſcertained by their mutual precipitations; but as diſtinct reguli are ſeldom obtained by theſe means, the operation ought to be frequently repeated, that the truth may be fully determined: the places of nickle and of cobalt are as yet uncertain. Gold, platina, zinc, and perhaps manganeſe, refuſe to unite with ſulphur, unleſs they be conjoined with ſome proper additament.

L.

Column Thirty-ninth, Saline Hepar.

SALINE liver of ſulphur has no place here, except in thoſe caſes in which it ſuffers no decompoſition. It diſſolves and retains almoſt all the metals, zinc alone excepted; but no one has aſcertained with what force it attracts them, and whether they can be mutually precipitated in the dry way. They can ſeldom be combined without fuſion; but when the combination is once formed, it is ſoluble in water. Mercury, however, and antimony, are diſſolved in the moiſt way, with the aſſiſtance of heat, which has not yet been aſcertained with reſpect to any other.

Hepar diſſolves charcoal both in the dry and moiſt way; the ſolution is of a green colour.

In the dry way, the metals precipitate one another more diſtinctly than when combined with ſulphur; the operations ſhould be repeated oftener than once, that we may be quite certain of the concluſions; and though I have ſeveral times made ſuch experiments, I have not yet attained ſo much certainty as I could have wiſhed. Meanwhile, I follow the order which my experiments have ſuggeſted; I leave it to be confirmed or corrected by future trials.

MANGANESE ſeems to have the ſame attractive force as iron; at leaſt I have not yet been able to ſeparate them by means of hepar. Next follow, iron, copper, tin, lead, ſilver, gold, antimony, cobalt, nickle, biſmuth, mercury, and arſenic. The places of the two laſt particularly are doubtful; nor are thoſe of gold and antimony ſatisfactorily ſettled.

LI.

Column Fortieth, Spirit of Wine.

I HERE ſuppoſe the ſpirit deprived, as much as poſſible, of ſuperfluous water; that I mean which does not enter into its compoſition. It attracts water very forcibly, inſomuch that æther diſſolved in it is ſeparated, at leaſt in great meaſure. Eſſential oils ſeem to adhere to it with leſs force than æther. It takes up pure alkalis, and hepar, but the order is as yet unſettled. The Count de Lauraguais has ſhewn how the vapours of ſulphur may be diſſolved in ſpirit of wine.

LII.

Column Forty-firſt, Æther.

THIS, as it were, intermediate ſubſtance between ſpirit of wine and eſſential oils, forcibly attracts ſpirit of wine, eſſential and unctuous oils. I cannot yet eſtabliſh with certainty the ſuperior force of either of the firſt mentioned ſubſtances. Such is its ſubtilty, that it diſſolves the elaſtic reſin, which, as well as ſulphur, may be precipitated by water.

LIII.

Column Forty-ſecond, Eſſential Oil.

These oils take up æther, ſpirit of wine, and ſulphur, but the ſeries has not been ſufficiently examined; nor can this eaſily be done, ſince they do not precipitate each other, but form triple compounds.

LIV.

Column Forty-third, Unctuous Oil.

Five ſubſtances occur here, but their places, if we except the laſt, are not clearly fixed. Some acids take up empyreumatic vegetable oils. Spirit of tartar, as it is called, abſorbs no ſmall portion of oil of tartar; and therefore, at the concluſion of the diſtillation, they ſhould be ſeparated, otherwiſe the oil will be ſenſibly diminiſhed by the acid. Vinegar has likewiſe this power.

LV.

Column Forty-fourth, Gold.

I HAVE already ſeveral times noticed the difference between the noble and ignoble metals. The king of metals, to ſpeak with the ancients, is directly attacked by dephlogiſticated muriatic acid, (XVII.) by aqua regia, (XVIII.) and nitrous acid, (XIV.); but the other acids, being deficient in power to carry off the neceſſary quantity of phlogiſton, do not take it up, unleſs it has been precipitated from ſome one of the three juſt mentioned. That a precipitate procured by alkali is a true calx of gold, is evident from the want of brilliancy, its ſolubility in aqua regia without producing red fumes, its power of tinging glaſs, &c. The calx is diſſolved by the acids of vitriol, arſenic, fluor, tartar, phoſphorus, fat, and above all, by the acid of ſea-ſalt in its entire ſtate; but the ſeries remains to be aſcertained. The acid of ants has not this power, at leaſt it does not turn yellow; the calx, however, ſoon grows black, but is not reduced, ſince it is taken up by muriatic acid. The ſame thing is true of vinegar; but inſtead of a black colour, an obſcure purple is produced. The acid of Pruſſian blue, ſaturated with calcareous earth, precipitates gold from aqua regia, in the form of white powder; but when too much is added, it diſſolves the ſediment. The powder of gold precipitated by alkali, in like manner grows white, when put into the acid of Pruſſian blue.

Æther takes gold from all the acids. It alſo directly diſſolves the calx, leaving gold itſelf, however minutely divided, quite untouched.

Calcined gold ſeems moreover to be ſoluble in alkali; for when it is added to a ſolution of gold, ſo as to exceed the point of ſaturation, there ſtill remains in the ſolution enough of the metal to produce a diſtinct yellow colour.

In the dry way, gold combines with all the metals; but in what order they are to be placed, can ſcarce be diſcovered, ſince three and more eaſily unite without the excluſion of any one, (VIII.). I have, however, placed thoſe uppermoſt to which it ſeems moſt willingly, and thoſe below to which it ſeems more re-

luctantly

luctantly to unite. The ſame thing holds with reſpect to moſt other metals, concerning which let this admonition ſuffice.

Gold is ſoluble in ſaline hepar, though it rejects ſulphur.

LVI.

Column Forty-fifth, Platina.

What has been juſt ſaid of gold, is applicable in great meaſure to platina, which, however, in the ſtate of a precipitate, is ſoluble in more acids, as in that of ſugar, ſorrel, lemon, ants, and in vinegar. The acid of Pruſſian blue ſeems to have no power either as a precipitant or a ſolvent.

That platina is always contaminated with iron, in my opinion, indicates nothing but the preſence of both metals in the places where platina is found. He alſo who ſhall conſider the great difficulty with which platina is fuſed, will not wonder that the alloy is defended by it ſo as ſcarce to be ſeparable. This is ſtrongly confirmed by the precipitate of platina from aqua regia by ſal ammoniac, which ſhews no veſtiges of iron, when it is well fuſed in microcoſmic ſalt *. It ſeems moſt probable that the magnetic power of the inherent iron is acquired by the triture in the iron mould, while the gold is amalgamated; it is at leaſt by this means contaminated with quickſilver. Scarce any platina is brought to Europe, which has not firſt undergone this operation. Gold mixed with iron in ſuch a proportion as to equal platina in ſpecific gravity, totally differs from it.

---

* Opuſc. vol. ii. p. 179.—181.

The experiments of the celebrated Dr Lewis ſeem to indicate that platina is in ſome degree attacked by liver of ſulphur.

LVII.

Column Forty-ſixth, Silver.

Muriatic acid attracts ſilver more ſtrongly than any other, and takes it from all the reſt. The acid of fat, however, ſeems to equal it. It is probable that the acid of Pruſſian blue is ſuperior to none but the aerial. By the former ſaturated with lime, ſilver is precipitated from vitriolic and nitrous acid, in the form of a white powder, but is rediſſolved when too much is added. The acid of ſugar ſeems to come next that of fat, for it decompoſes lunar vitriol by attracting its metallic baſis: nitrated ſilver is precipitated by the vitriolic acid, by that of ſugar of milk, and likewiſe by the arſenical acid, but ſo imperfectly that it ſhould, in appearance, be placed after that of nitre. The places of the following acids are leſs certainly determined. Silver precipitated by cryſtallized alkali is ſoluble in aerial acid, which may again be expelled by fire; aerated ſilver, however, is not taken up by water. Vitriolated ſilver is not precipitated by aerial acid, unleſs it contain a mixture of muriatic acid.

PURE volatile alkali diſſolves calcined ſilver, and the ſolution will afford cryſtals. There is a new claſs of ſalts, conſiſting of metals diſſolved in alkalis, highly worthy of attention, though they have as yet been but little, or not at all, examined.

LVIII.

Column Forty-ſeventh, Mercury.

Mercury, in point of fuſibility, conſtitutes one extreme among the metals, and platina the other. The former requires only ſuch a degree of heat as is rarely wanting in our atmoſphere, but when the cold is increaſed by art to the temperature denoted by 40° of the Swediſh thermometer, this metal likewiſe begins to concrete, and, in due time, becomes quite hard. Dr Pallas ſays that it was ſeveral times congealed in Siberia by the natural cold. In its common ſtate, therefore, it is to be conſidered as a metal in fuſion; and ſince, in its ſolid ſtate, it is nearly as malleable as lead, it by no means ought to be placed among the ſemimetals, otherwiſe the whole claſs muſt be conſidered as brittle, for none is malleable when in fuſion.

Acid of fat is placed firſt, for it diſengages all the reſt, even the muriatic, to which the ſecond place belongs. The acids of ſugar, ſorrel, amber, arſenic, and phoſphorus, ſoon expel the vitriolic and nitrous, and fall with the calx of quickſilver to the bottom; but their reſpective forces have not been ſufficiently compared: acid of ſugar of milk precipitates mercury, but yields to the muriatic, but whether to the vitriolic and thoſe yet ſtronger, is uncertain. Acid of lemon produces a copious precipitation of mercury, diſſolved in the cold in nitrous acid, though but a ſparing one when the ſolution is forwarded by heat. The ſame holds with reſpect to the acid of tartar, of which it is moreover certain that it yields to the vitriolic. The fluor acid ſeems to be weaker than the nitrous: the acid of ants does not, as we learn from Margraaf, diſſolve, but reduce the calx. The ſtations of acetous acid, phlogiſticated vitriolic acid, and the acid of borax, remain to be aſcertained with greater accuracy. The calx of mercury, precipitated by mild alkali, combines with the aerial acid; but this metallic ſalt is not ſoluble in water. The acid of Pruſſian blue decompoſes aerated mercury, and forms cryſtals. This acid precipitates ſilver from its ſolution in nitrous acid, when made in the cold, in the form of a black powder. Whether it prevails over the vitriolic, and thoſe ſtill ſtronger, by its ſingle power, has not yet been determined by experiment.

LIX.

Column Forty-eighth, Lead.

The vitriolic acid attracts lead with greater force than any other, and immediately takes it from them. The acid of Pruſſian blue, alone, has no power; but by a double attraction a white powder is ſeparated, which cannot be rediſſolved by adding an exceſs of the precipitant. The acids of fat, of ſugar of milk, ſugar, arſenic, tartar, phoſphorus, and ſorrel, certainly expel the muriatic and nitrous acids, at the ſame time forming new compounds ſcarce ſoluble; but their reſpective order requires to be aſcertained by farther examination. The fluor acid prevails over vinegar, as alſo do probably the acids of lemon and ants. To the reſt, the obſervations in LVIII. are applicable. The calx of lead, when it contains no aerial acid, ſeems to attract it with the ſame force as fixed alkali, for the calx in this ſtate renders the alkali cauſtic in part, as reciprocally happens to the aerated calx when put into the cauſtic ley.

Pure fixed alkali, and alſo unctuous oil, diſſolve the calx of lead.

LX.

Column Forty-ninth, Copper.

Acid of ſugar occupies the higheſt rectangle, ſince when it is dropped into vitriolated or muriated copper, it ſeizes the metal, and exhibits at the bottom of the veſſel a greeniſh ſky-blue powder. Acid of tartar likewiſe precipitates theſe ſalts, but not ſo quickly; it forms blue cryſtals. The muriatic acid is ſuperior to the vitriolic, for blue vitriol is readily diſſolved in it; the menſtruum ſoon grows green, and yields a yellow ſympathetic ink, which cannot be obtained without muriated copper; not however to truſt to the colour alone, I add highly rectified ſpirit of wine to muriatic acid, ſaturated with vitriol; no ſeparation, however, took place, as neceſſarily happens whenever copper is united with vitriolic acid. At the ſame time, let it be obſerved, that a very ſmall degree of heat, even the rays of the ſun, reſtore the ſuperiority to vitriolic acid, inſomuch, that cryſtals of vitriol are at laſt obtained, or may indeed be ſeparated by ſpirit of wine without evaporation. This is a remarkable inſtance of the power of heat, (IV.). The muriatic acid dropped into a ſolution of nitrated copper, precipitates a white ſaline powder, conſiſting of marine acid and the calx of copper in exceſs: this powder is not ſoluble in water. The acid of fat, of ſugar of milk, and of nitre, are expelled by the vitriolic, and the acetous by the arſenical; but the ſtrength of the reſt has not been ſufficiently examined. The Pruſſian acid, without aſſiſtance, decompoſes aerated copper; but ſcarce any other compound of this metal. When combined with alkali, it decompoſes them all, by means of a double attraction, and the precipitates are rediſſolved when too much is added. The other acids take up only part of theſe ſediments; what remains is of a white colour. Volatile alkali totally diſſolves them; the colour of the ſolution is a bluiſh green, but they are again precipitated by water.

ALKALIS and oils attack copper, but in what order is not known.

LXI.

Column Fiftieth, Iron.

Acid of ſugar immediately turns a ſolution of martial vitriol yellow, and gradually ſeparates a yellow powder, conſiſting of the calx of iron, and the added acid. The acid of tartar, in like manner, decompoſes it; but the new ſalt does not ſo ſoon become viſible, and it is more cryſtalline. Green vitriol, diſſolved in muriatic acid, is ſeparated by ſpirit of wine, and therefore the vitriolic is to be placed firſt. Acid of ſugar of milk is incapable of ſeparating the vitriolic acid; and the acid of fat yields to the nitrous. Pruſſian blue is diſſolved by its own acid; the ſolution is of a yellow colour: other acids have no action upon it, which would ſeem to ſhew that this acid has the ſtrongeſt attraction for iron; and it does indeed precipitate it from the aerial acid, but from no other, as far as I know, unleſs it is ſaturated with alkali, that is, by means of a double elective attraction. The following places remain to be confirmed by farther experiment; it is, however, certain that the acetous acid is inferior to the arſenical.

LXII.

Column Fifty-firſt, Tin.

In almoſt the whole of this column the ſeries is doubtful, and very difficult to be aſcertained, ſince tin requires an exceſs of acid to be ſuſpended. It is certain that the acids of arſenic, and ſugar of milk, yield to the vitriolic and marine, while they are ſuperior to the acetous. The acid of fat exceeds the marine in ſtrength of attraction.

Both fixed and volatile alkali attack calx of tin.

LXIII.

Column Fifty-ſecond, Biſmuth.

Bismuth readily diſſolves in nitrous acid; but the acids of ſugar, fat, ſorrel, tartar, phoſphorus, and arſenic, when added to this compound, attract the baſis; but their relative powers are undetermined: the new compounds fall to the bottom ſcarce ſoluble, in the form of very fine powder, except only tartarized biſmuth, which, however, affords pellucid cryſtalline grains, in 10—15 minutes. As water alone cauſes a precipitation, I either employed a ſolution with ſuch an exceſs of acid, that a number of drops of water, equal to that of the precipitants, cauſed no permanent cloudineſs, or elſe added acids, which may be procured in a concrete form, as moſt of thoſe juſt mentioned. Theſe acids, in like manner, decompoſe a ſolution of biſmuth in the vitriolic acid: which menſtruum, when diluted, attacks the calx; but to diſſolve the regulus, it muſt be in a concentrated ſtate; and, in order to ſeparate the phlogiſton, it muſt be evaporated to dryneſs.

Distilled vinegar boiled with the calx of biſmuth for half an hour, does, in reality, diſſolve part, as appears from the taſte, the addition of phlogiſticated alkali, and the above mentioned acids; what is diſſolved cannot be precipitated by water, unleſs perhaps in great quantity, and by long ſtanding. The regulus is diſſolved in the ſame manner, but ſo ſparingly that it can ſcarce be aſcertained. What has been ſaid concerning vinegar, is likewiſe applicable to acid of ants. The remaining places are uncertain, nor are even the reſpective powers of vitriolic, nitrous, and marine acid determined.

LXIV.

Column Fifty-third, Nickle.

Nickle is not yet univerſally acknowledged as a diſtinct metal; but as it may be diſtinguiſhed from others by conſtant criterions, ſuch as its deep green colour, when diſſolved in thoſe acids which attack it; its blue colour in volatile alkali; the greeniſh white precipitate it yields on the addition, either of common or phlogiſticated alkali; the hyacinthine tinge it communicates to glaſs, characteriſtics which, taken together, belong to no other; moreover, ſince when it is properly purified, it cannot be reſolved into others, though it be ever ſo long tortured, both in the dry and moiſt way; laſtly, ſince no one has produced by ſyntheſis, a mixture agreeing with nickle in the properties above mentioned, from copper, arſenic, purified cobalt, iron, or other metals fuſed together; for theſe ſeveral reaſons, I cannot but conſider nickle as a diſtinct metal, till I am better informed by new experiments. Moſt chemiſts have been ſeduced by the extreme difficulty which attends the purification of it. It is indeed always contaminated with arſenic, cobalt and iron, ſometimes alſo with copper and other metals. Copper is eaſily ſeparated, arſenic with great difficulty, the laſt veſtiges of cobalt with ſtill greater, but iron by no method hitherto diſcovered, as is related more at length in my diſſertation on this metal. I do not, therefore, wonder that nickle, if it be ſo ſparingly contaminated with cobalt, that the particles of the former metal ſurround thoſe of the latter on every ſide, ſhould not afford, according to the common method, glaſs of a green colour, and yet that this colour ſhould appear on the addition of white arſenic; for this addition not only weakens the coheſion of the cobalt and nickle, but renders the maſs more fluid, and deprives the cobalt of the phlogiſton which before prevented the effect. Cobalt does not tinge glaſs, except when in the ſtate of calx; this calx contains a wonderful ſtore of colours; but when exceſſively dephlogiſticated, it cannot either be fuſed or reduced, without great difficulty. Nickle contaminated with iron alone, which I have not been able to remove by any means, is malleable, and very tenacious, ſo that I doubt whether it ought to be reckoned among the brittle metals. It is ſometimes magnetic, is difficult of fuſion, and does not yield a blue glaſs on the addition of white arſenic; it, however, gives a very deep green to acid menſtrua, and ſhews the above mentioned criterions.

Nickle prefers no acid to that of ſugar; by this it is taken from every other, and appears in the form of a whitiſh green inſoluble powder: It is likewiſe precipitated by acid of ſorrel. The acid of fat yields to the nitrous. The other places remain to be determined by farther examination; the trials, however, that have been made, ſeem to indicate that the arſenical acid is to be placed after the acetous.

LXV.

Column Fifty-fourth, Arſenic.

The ſolutions of arſenic are, in ſome meaſure, imperfect, at which we need not be ſurpriſed, the calx being only a real acid, coagulated by phlogiſton, (XX.). It has, however, as yet been little examined, with a view to its elective attractions. That the vitriolic acid yields to the muriatic, appears from this, that arſenic, diſſolved in the former, yields, upon addition of the latter, and expoſure to a very gentle heat, butter of arſenic. The vitriolic is likewiſe extruded by the ſaccharine, and the ſebaceous by the nitrous. The reſt is doubtful.

LXVI.

Column Fifty-fifth, Cobalt.

Cobalt differs from nickle, in imparting a red colour to all the acids, and volatile alkali, when it is diſſolved in them; in the reddiſh aſh-coloured precipitate thrown down either by common or phlogiſticated alkali; in attracting ſaline hepar from nickle in the dry way; in refuſing to combine with ſilver, biſmuth and lead by fuſion, which metals do not reject nickle unleſs it contain too much cobalt; in the ſuperior richneſs of its colour; for which reaſon, though it be preſent in the ſame maſs, in far leſs quantity than nickle, yet it prevails; for a regulus containing a much larger portion of nickle, yields nevertheleſs a red ſolution in acids, without any ſhade of green, and with a ſtill more inconſiderable alloy, it tinges glaſs of a blue colour.

Cobalt is moſt ſtrongly attracted by acid of ſugar, which precipitates it from other acids, in the form of a pale roſe-coloured powder; and as it is very difficult of ſolution in water, unleſs a great exceſs of acid be preſent, its power of attraction has not yet been compared with that of the acid of ſorrel, which likewiſe precipitates cobalt from the muriatic, and other acids. The vitriolic is expelled by the muriatic acid, as may be ſhewn in various ways. Highly rectified ſpirit of wine refuſes vitriol of cobalt, but not muriated cobalt. Since, therefore, a ſolution of this vitriol in marine acid, affords no precipitate on the addition of ſpirit of wine, it is evident that the vitriol muſt have been decompoſed. Beſides, muriated cobalt (but not vitriolated) yields ſympathetic ink;

now a ſolution of vitriol, upon the addition of muriatic acid, (or of ſea-ſalt, which contains it, and then the decompoſition is effected by a double attraction), immediately acquires this property, and in a dry ſtate of the air, writing is turned green, and becomes legible. I ſay, when the air is dry, for when the letters are inviſible, if the paper be put over newly burned lime, or concentrated vitriolic acid, in a cloſe phial, they ſoon become manifeſt. Fire, therefore, or heat, acts only by drying, which is agreeable to Hellot's explanation. Cobalt precipitated with phlogiſticated alkali, is neither ſoluble in phlogiſticated alkali, nor acids.

Acid of arſenic is incapable of taking cobalt from vinegar, at leaſt it cauſes no precipitation. The other places remain to be further examined.

LXVII.

Column Fifty-ſixth, Zinc.

Acid of ſugar takes zinc from every other acid, and when united with it, immediately falls to the bottom in the form of a white powder; but the acid of ſugar of milk yields to the vitriolic, and that of fat to the nitrous. Zinc precipitated by phlogiſticated alkali is not acted upon by an exceſs of it; but it is taken up by acids. Vitriolic, nitrous, and muriatic acids, prevail over that of arſenic; but the acetous yields to it. Vitriolic acid comes before the muriatic; for vitriol of zinc, diſſolved in acid of ſalt, is precipitated by ſpirit of wine. Acid of ſorrel has not been tried; but if I miſtake not, it will be found to expel the vitriolic.

LXVIII.

Column Fifty-ſeventh, Antimony.

THE attractions of antimony have as yet been but little examined; the examination is indeed attended with difficulty, ſince the ſolutions require an exceſs of acid. The firſt place belongs to the acid of fat, and the next to the muriatic; the vitriolic is expelled by the ſaccharine. The vitriolic, nitrous, and muriatic, are ſuperior to the arſenical; to which, however, the acetous yields. I have not yet been able to aſcertain a greater number with accuracy.

LXIX.

*Column Fifty-eighth, Mangane*ſ*e.*

The ſpecific gravity of magneſia nigra, the property it poſſeſſes of tinging glaſs, and, above all, the white precipitate produced by phlogiſticated alkali, in ſolutions made in every acid, led me, many years ago, to perceive diſtinctly that this ſubſtance contained a peculiar metal. Dr Gahn, who was formerly my pupil, firſt eliquated the regulus, which has moſt diſtinguiſhing properties; and ſince neither analytic experiments have reſolved it into others, nor ſynthetic compoſed one with the ſame properties, it is proper to diſtinguiſh it. Mangāneſe in its metallic ſtate is hard, brittle, has a granular, white and ſhining fracture; and ſuch is its refractorineſs, that it is more difficult of fuſion than iron, whence I at firſt conjectured, that it was the ſame as platina; it ſeems to refuſe ſulphur; it yields a perfectly pellucid and colourleſs vitriol, of which the cryſtals are parallelopipeds. The calx, when deprived of almoſt all its phlogiſton, is black; but when it has a ſufficient quantity to be capable of ſolution in acids, it is white; when in combination with a ſtill larger portion, it acquires a reguline nature. The black calx, in the fire, gives an hyacinthine tinge to borax, and a purple one to microcoſmic ſalt; but on the addition of a ſufficient quantity of phlogiſton, both colours diſappear. This metal parts with great difficulty from all its iron; but who knows not the difficulty of ſeparating the laſt veſtiges of foreign matter, when it is ſurrounded by other particles, which attract them ſtrongly, eſpecially if the mixture be refractory?

The black calx is taken up indeed by the vitriolic and marine acids, but the ſolutions are coloured, and never without a tinge, unleſs an addition of ſugar, or ſome other matter, be added to ſupply the neceſſary phlogiſton; but it is perfectly diſſolved in acids, either artificially phlogiſticated, as thoſe of vitriol and nitre, or thoſe naturally containing inflammable matter, as thoſe of lemon and tartar; and it decompoſes them at the ſame time.

The acids of ſugar, tartar, ſorrel, lemon, phoſphorus, and fluor, expel the nitrous, vitriolic, and marine; for when vitriol of manganeſe is diſſolved in them, there appear ſmaller cryſtals, eaſily ſoluble in ſpirit of wine, which totally rejects vitriol; and, moreover, the ſolution in which the cryſtalline grains are immerſed, when poured off, afforded no precipitation on the addition of ſpirit of wine. The acids of nitre, fat, and arſenic, expel the acetous. The reſt is doubtful.

In the dry way, copper, iron, gold, ſilver, tin, and ſiderite, combine with manganeſe. The other metals remain to be tried. Liver of ſulphur ſcarce ſeparates the alloy of iron, but diſſolves both metals together.

LXX.

Column Fifty-ninth, Siderite.

This metal, which renders iron cold-ſhort, ſeems to me to be different from all others. The few circumſtances which I have hitherto been able to obſerve concerning it, may be ſeen in my eſſay on that ſubject. Much remains for inveſtigation; and I have been obliged to put off my reſearches for want of materials to work upon. The three common mineral acids diſſolve it, but with difficulty. In the ſeries of precipitations by metals, ſiderite ſeems to ſtand higher than lead. It cannot, any more than tin, be precipitated in a metallic form, but always falls down in the ſtate of a calx.

Such is this extenſive ſubject, and ſuch a multitude of experiments and obſervations does it ſtill demand. I have diſtinguiſhed what is certain from that which remains doubtful, that it may appear what remains to be done by him who wiſhes to try his powers and patience in the cultivation of this ſcience. The ſtations which are ambiguous or doubtful, have not been aſſigned totally without reaſon, though indeed inſufficient to produce full conviction. Moreover, if I have any where erred, the condition of humanity muſt plead my excuſe. I do not, however, doubt but that many aſſertions, which ſhall ſeem obſcure, or perhaps falſe, to ſome, will be quite plain and evident to him who ſhall ſeriouſly apply to this taſk.

E N D.

SINGLE ELECTIVE A

In the Moist Way.

	1	2	3	4	5	6	7	8	9	10	11	
1	Vitriolic A	Phlogisticated vitriolic Acid	Nitrous Acid	Phlogisticated nitrous Acid	Marine Acid	Dephlogisticated marine Acid	Aqua Regia	Acid of Fluor	Acid of Arsenic	Acid of Borax	Acid of Sugar	Aci
2	Pure ponderous earth	ure ponderous rth	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Lime	Lime	Lime	Lime	Lim
3	Pure vegetable alkali	P e vegetable alka	Pure foſſil alkali?	Pure foſſil alkali?	Pure foſſil alkali?	Pure foſſil alkali?	Pure foſſil alkali?	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure earth
4	Pure foſſil alkali	Pur offil alkali	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure
5	Lime	Lime	Lime	Lime	Lime	Lime	Lime	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure kali
6	Pure magneſia	Pur magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure
7	Pure volatile alkali	ure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure
8	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure
9	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx
10	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx
11	Calx of mangaueſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx
12	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx
13	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx
14	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx
15	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx
16	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx
17	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx
18	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx
19	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx
20	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx
21	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx
22	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx
23	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx
24	Water	Water	Water	Water	Water	Water	Water	Water	Phlogiſton	Water	Water	Wat
25	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Water	Spirit of wine	Spirit of wine	Spiri
26	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Pure ſiliceous earth	Spirit of wine	Phlogiſton	Phlogiſton	Phlo
27												
28												
29												
30												

In the Dry Way.

	1	2	3	4	5	6	7	8	9	10	11	
31	Phlogiſton		Phlogiſton		Phlogiſton		Phlogiſton		Phlogiſton			
32	Pure vegetable alkali		Pure ponderous earth?		Pure ponderous earth?		Pure ponderous earth?	Lime	Lime	Lime		
33	Pure foſſil alkali		Pure vegetable alkali		Pure vegetable alkali		Pure vegetable alkali	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth		
34	Pure pond. earth		Pure foſſil alkali		Pure foſſil alkali		Pure foſſil alkali	Pure magneſia	Pure magneſia	Pure magneſia		
35	Lime		Lime		Lime		Lime	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali		
36	Pure magneſia		Pure magneſia		Pure magneſia		Pure magneſia	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali		
37	Metallic calces		Metallic calces		Metallic calces		Metallic calces	Metallic calces	Metallic calces	Metallic calces		
38	Pure volatile alkali		Pure volatile alkali		Pure volatile alkali		Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali		
39	Pure clay		Pure clay		Pure clay		Pure clay	Pure clay	Pure clay	Pure clay		
40												
41												
42												
43												
44												
45												
46												
47												
48												
49												
50												

SINGLE ELECTIVE

In the MOIST

	21	22	23	24	25	26	27	28	29	30	
1	Acid of Fat	Acid of Phosphorus	Acidum Perlatum	Acid of Prussian Blue	Aerial Acid	Pure Vegetable Alkali	Pure Fossil Alkali	Pure Volatile Alkali	Pure Ponderous Earth	Lime	Pure
2	Lime	Lime	Lime	Pure vegetable alkali	Pure ponderous earth	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid	Acid of ſugar	Acid o
3	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure foſſil alkali	Lime	Nitrous acid	Nitrous acid	Nitrous acid	Acid of ſugar	Acid of ſorrel	Acid o rus
4	Pure magneſia	Pure magneſia	Pure magneſia	Pure volatile alkali	Pure vegetable alkali	Marine acid	Marine acid	Marine acid	Acid of amber	Vitriolic acid	Acidu
5	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Lime	Pure foſſil alkali	Acid of fat	Acid of fat	Acid of fat	Fluor acid	Acid of tartar	Vitrio
6	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure ponderous earth	Pure magneſia	Fluor acid	Fluor acid	Fluor acid	Acid of ſorrel	Acid of amber	Fluor
7	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure magneſia	Pure volatile alkali	Phoſphoric acid	Phoſphoric acid	Phoſphoric acid	Phoſphoric acid	Phoſphoric acid	Acid
8	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Acid of ſugar	Acid of ſugar	Acid of ſugar	Acidum perlatum	Acidum perlatum	Acid
9	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Acid of tartar	Acid of tartar	Acid of tartar	Acid of ſugar of milk	Acid of ſugar of milk	Acid milk
10	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Acid of arſenic	Acid of arſenic	Acid of arſenic	Nitrous acid	Nitrous acid	Acid
11	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Acid of ſorrel	Acid of ſorrel	Acid of ſorrel	Marine acid	Marine acid	Nitro
12	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Acid of amber	Acid of amber	Acid of amber	Acid of fat	Acid of fat	Marin
13	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Acid of lemon	Acid of lemon	Acid of lemon	Acid of lemon	Fluor acid	Acid
14	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Acid of ants	Acid of ants	Acid of ants	Acid of tartar	Acid of arſenic	Acid
15	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Acid of milk	Acid of milk	Acid of milk	Acid of arſenic	Acid of ants	Acid
16	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of ants	Acid of milk	Acid
17	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Acetous acid	Acetous acid	Acetous acid	Acid of milk	Acid of lemon	Acid
18	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Acidum perlatum	Acidum perlatum	Acidum perlatum	Acid of benzoin	Acid of benzoin	Acid
19	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Acid of ſugar of milk	Acid of ſugar of milk	Acid of ſugar of milk	Acetous acid	Acetous acid	Acet
20	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Acid of borax	Acid of borax	Acid of borax	Acid of borax	Acid of borax	Acid
21	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Phlogiſticated vitriolic acid	Phlogiſticated vitriolic acid	Phlogiſticated vitriolic acid	Phlogiſticated vitriolic acid	Phlogiſticated vitriolic acid	Phlog trioli
22	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Phlogiſticated nitrous acid	Phlogiſticated nitrous acid	Phlogiſticated nitrous acid	Phlogiſticated nitrous acid	Phlogiſticated nitrous acid	Phlog trous
23	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Aerial acid	Aerial acid	Aerial acid	Aerial acid	Aerial acid	Aeria
24	Water	Water	Water	Water	Water	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid blue
25	Spirit of wine	Spirit of wine			Spirit of wine	Water	Water	Water	Water	Water	
26	Phlogiſton	Phlogiſton	Phlogiſton			Unctuous oils	Unctuous oils	Unctuous oils	Unctuous oils	Unctuous oils	
27						Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulph
28						Metallic calces	Metallic calces	Phlogiſton			
29											
30											

In the DRY

	21	22	23	24	25	26	27	28	29	30	
31						Phoſphoric acid	Phoſphoric acid		Phoſphoric acid	Phoſphoric acid	Phoſp
32	Lime	Lime	Lime			Acidum perlatum	Acidum perlatum		Acidum perlatum	Acidum perlatum	Acid
33	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth			Acid of borax	Acid of borax		Acid of borax	Acid of borax	Acid
34	Pure magneſia	Pure magneſia	Pure magneſia			Acid of arſenic	Acid of arſenic		Acid of arſenic	Acid of arſenic	Acid
35	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali			Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitri
36	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali			Nitrous acid	Nitrous acid	Nitrous acid	Acid of amber	Acid of amber	Acid
37	Metallic calces	Metallic calces	Metallic calces			Marine acid	Marine acid	Marine acid	Fluor acid	Nitrous acid	Acid
38	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali			Acid of fat	Acid of fat	Acid of fat	Nitrous acid	Marine acid	Acid
39	Pure clay	Pure clay	Pure clay			Fluor acid	Fluor acid	Fluor acid	Marine acid	Acid of fat	Nitro
40						Acid of amber	Acid of amber	Acid of amber	Acid of fat	Fluor acid	Marin
41						Acid of ants	Acid of ants	Acid of ants	Acid of ants	Acid of ants	Acid
42						Acid of milk	Acid of milk	Acid of milk	Acid of milk	Acid of milk	Acid
43						Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid
44						Acetous acid	Acetous acid	Acetous acid	Acetous acid	Acetous acid	Aceto
45						Pure ponderous earth	Pure ponderous earth	Pure ponderous earth			
46						Lime	Lime	Lime	Pure fixed alkali	Pure fixed alkali	Pure f
47						Pure magneſia	Pure magneſia	Pure magneſia			
48						Pure clay	Pure clay	Pure clay	Sulphur	Sulphur	Sulphu
49						Pure ſiliceous earth	Pure ſiliceous earth	Pure ſiliceous earth			
50						Sulphur	Sulphur	Sulphur	Calx of lead	Calx of lead	Calx o

VE ATTRACTIONS.

MOIST WAY.

No. II.

	31 Pure Magneſia	32 Pure Clay	33 Pure Siliceous Earth	34 Water	35 Vital Air	36 Phlogiston	37 Matter of Heat	38 Sulphur	39 Saline Liver of Sulphur	40 Alcohol	1
	Acid of ſugar	Vitriolic acid	Acid of fluor	Pure vegetable alkali	Phlogiſton	Nitrous acid	Vital air	Calx of lead	Calx of gold	Water	2
	Acid of phoſphorus	Nitrous acid	Pure vegetable alkali	Pure foſſil alkali		Vitriolic acid	Æther	Calx of tin	Calx of ſilver	Æther	3
	Acidum perlatum	Marine acid		Pure volatile alkali		Dephlogiſticated marine acid	Alcohol	Calx of ſilver	Calx of mercury	Eſſential oils	4
	Vitriolic acid	Acid of ſugar		Alcohol		Acid of arſenic	Pure volatile alkali	Calx of mercury	Calx of arſenic	Pure volatile alkali	5
r	Fluor acid	Acid of arſenic		Aerated volatile alkali		Phoſphoric acid	Water	Calx of arſenic	Calx of antimony	Pure fixed alkali	6
d	Acid of fat	Fluor acid		Vitriolated foſſil alkali			Eſſential oils	Calx of antimony	Calx of biſmuth	Saline hepar	7
tum	Acid of arſenic	Acid of fat		Æther		Calx of platina	Glaſs	Calx of iron	Calx of copper	Sulphur	8
of	Acid of ſugar of milk	Acid of ſorrel				Calx of gold	Mercury	Pure fixed vegetable alkali	Calx of tin		9
	Acid of amber	Acid of tartar				Calx of ſilver		Pure volatile alkali	Calx of lead		10
	Nitrous acid	Acid of amber				Calx of mercury		Pure ponderous earth	Calx of nickle		11
	Marine acid	Acid of ſugar of milk				Calx of arſenic		Lime	Calx of cobalt		12
	Acid of ſorrel	Acid of lemon				Calx of antimony		Pure magneſia	Calx of manganeſe		13
ic	Acid of tartar	Acid of phoſphorus				Calx of biſmuth			Calx of iron		14
	Acid of lemon	Acidum perlatum		Vitriolic acid		Calx of copper					15
	Acid of ants	Acid of ants		Vitriolated vegetable alkali		Calx of tin					16
n	Acid of milk	Acid of milk		Vitriolated clay		Calx of lead					17
oin	Acid of benzoin	Acid of benzoin		Vitriolated iron		Calx of nickle					18
	Acetous acid	Acetous acid		Corroſive ſublimate mercury		Calx of cobalt					19
x	Acid of borax	Acid of borax				Calx of manganeſe					20
d vi-	Phlogiſticated vitriolic acid	Phlogiſticated vitriolic acid				Calx of iron					21
d ni-	Phlogiſticated nitrous acid	Phlogiſticated nitrous acid				Calx of zinc					22
	Aerial acid	Aerial acid									23
ian	Acid of Pruſſian blue	Acid of Pruſſian blue									24
											25
								Unctuous oil			26
	Sulphur							Eſſential oil			27
								Æther			28
								Alcohol	Alcohol		29
						Water			Water		30

DRY WAY.

	31 Pure Magneſia	32 Pure Clay	33 Pure Siliceous Earth	34 Water	35 Vital Air	36 Phlogiston	37 Matter of Heat	38 Sulphur	39 Saline Liver of Sulphur	40 Alcohol	
cid	Phoſphoric acid	Phoſphoric acid				Calx of platina		Pure fixed alkali	Manganeſe		31
atum	Acidum perlatum	Acidum perlatum				Calx of gold		Iron	Iron		32
x	Acid of borax	Acid of borax				Acid of arſenic		Copper	Copper		33
ic	Acid of arſenic	Acid of arſenic				Calx of ſilver		Tin	Tin		34
	Vitriolic acid	Vitriolic acid				Calx of mercury		Lead	Lead		35
er	Acid of fluor	Nitrous acid				Calx of arſenic		Silver	Silver		36
	Acid of fat	Marine acid				Calx of antimony		Cobalt	Gold		37
	Acid of amber	Fluor acid				Calx of biſmuth		Nickle	Antimony		38
	Nitrous acid	Acid of fat				Calx of copper		Biſmuth	Cobalt		39
	Marine acid	Acid of amber				Calx of tin		Antimony	Nickle		40
	Acid of ants	Acid of ants				Calx of lead		Mercury	Biſmuth		41
	Acid of milk	Acid of milk				Calx of nickle		Arſenic	Mercury		42
oin	Acid of benzoin	Acid of benzoin				Calx of cobalt			Arſenic		43
	Acetous acid	Acetous acid				Calx of manganeſe					44
						Calx of iron					45
ali	Pure fixed alkali	Pure fixed alkali	Pure fixed alkali			Calx of zinc					46
											47
	Sulphur	Sulphur	Phoſphoric acid								48
											49
	Calx of lead	Calx of lead	Calx of lead								50

SINGLE ELECTIV

In the Moist W

1	42 Æther	42 Essential Oils	43 Expressed Oils	44 Calx of Gold	45 Calx of Platina	46 Calx of Silver	47 Calx of Mercury	48 Calx of Lead	49 Calx of Copper	50 Calx of Iron
2	Alcohol	Æther	Æther	Æther	Æther	Marine acid	Acid of fat	Vitriolic acid	Acid of ſugar	Acid of ſugar
3	Eſſential oils	Alcohol	Eſſential oils	Marine acid	Marine acid	Acid of fat	Marine acid	Acid of fat	Acid of tartar	Acid of tartar
4	Expreſſed oils	Expreſſed oils	Pure fixed alkali	Aqua regia	Aqua regia	Acid of ſugar	Acid of ſugar	Acid of ſugar of milk	Marine acid	Vitriolic acid
5	Water	Pure fixed alkali	Pure volatile alkali	Nitrous acid	Nitrous acid	Vitriolic acid	Acid of amber	Acid of ſugar	Vitriolic acid	Acid of ſugar o milk
6	Sulphur	Sulphur	Sulphur	Vitriolic acid	Vitriolic acid	Acid of ſugar of milk	Arſenical acid	Arſenical acid	Acid of ſugar of milk	Marine acid
7				Arſenical acid	Arſenical acid	Phoſphoric acid	Phoſphoric acid	Acid of tartar	Nitrous acid	Nitrous acid
8				Fluor acid	Fluor acid	Nitrous acid	Vitriolic acid	Phoſphoric acid	Acid of fat	Acid of fat
9				Acid of tartar	Acid of tartar	Arſenical acid	Acid of ſugar of milk	Acid of ſorrel	Arſenical acid	Phoſphoric acid
10				Phoſphoric acid	Phoſphoric acid	Fluor acid	Acid of tartar	Marine acid	Phoſphoric acid	Arſenical acid
11				Acid of fat	Acid of fat	Acid of tartar	Acid of lemon	Nitrous acid	Acid of ſorrel	Acid of ſorrel
12				Acid of Pruſſian blue	Acid of ſugar	Acid of ſorrel	Nitrous acid	Fluor acid	Acid of amber	Fluor acid
13					Acid of ſorrel	Acid of lemon	Fluor acid	Acid of lemon	Fluor acid	Acid of amber
14					Acid of lemon	Acid of ants	Acetous acid	Acid of ants	Acid of lemon	Acid of lemon
15					Acid of ants	Acid of milk	Acid of borax	Acid of milk	Acid of ants	Acid of ants
16					Acid of milk	Acetous acid	Acid of Pruſſian blue	Acetous acid	Acid of milk	Acid of milk
17					Acetous acid	Acid of amber	Aerial acid	Acid of borax	Acetous acid	Acetous acid
18					Acid of amber	Acid of Pruſſian blue		Acid of Pruſſian blue	Acid of borax	Acid of borax
19						Aerial acid		Aerial acid	Acid of Pruſſian blue	Acid of Pruſſian blue
20				Fixed alkali				Pure fixed alkali	Aerial acid	Aerial acid
21				Volatile alkali		Pure volatile alkali			Pure fixed alkali	
									Pure volatile alkali	
23									Expreſſed oils	
24										
25										
26										
27										
28										
29										
30										

In the Dry W

31				Gold	Platina	Silver	Mercury	Lead	Copper	Iron
32				Mercury	Arſenic	Lead	Gold	Gold	Gold	Nickle
33				Copper	Gold	Copper	Silver	Silver	Silver	Cobalt
34				Silver	Copper	Mercury	Platina	Copper	Arſenic	Manganeſe
35				Lead	Tin	Biſmuth	Lead	Mercury	Iron	Arſenic
36				Biſmuth	Biſmuth	Tin	Tin	Biſmuth	Manganeſe	Copper
37				Tin	Zinc	Gold	Zinc	Tin	Zinc	Gold
38				Antimony	Antimony	Antimony	Biſmuth	Antimony	Antimony	Silver
39				Iron	Nickle	Iron	Copper	Platina	Platina	Tin
40				Platina	Cobalt	Manganeſe	Antimony	Arſenic	Tin	Antimony
41				Zinc	Manganeſe	Zinc	Arſenic	Zinc	Lead	Platina
42				Nickle	Iron	Arſenic	Iron	Nickle	Nickle	Biſmuth
43				Arſenic	Lead	Nickle		Iron	Biſmuth	Lead
44				Cobalt	Silver	Platina			Cobalt	Mercury
45				Manganeſe	Mercury				Mercury	
46										
47				Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur
48						Sulphur	Sulphur	Sulphur	Sulphur	Sulphur
49										
50										

VE ATTRACTIONS.

OIST WAY.

No. III.

50 f Iron	51 Calx of Tin	52 Calx of Bismuth	53 Calx of Nickle	54 Calx of Arsenic	55 Calx of Cobalt	56 Calx of Zinc	57 Calx of Antimony	58 Calx of Manganese	59 Calx of Siderite	1
f ſugar	Acid of fat	Acid of ſugar	Acid of ſugar	Marine acid	Acid of ſugar	Acid of ſugar	Acid of fat	Acid of ſugar	Vitriolic acid	2
f tartar	Acid of tartar	Acid of arſenic	Acid of ſorrel	Acid of ſugar	Acid of ſorrel	Vitriolic acid	Marine acid	Acid of ſorrel	Nitrous acid	3
ic acid	Marine acid	Acid of ſorrel	Marine acid	Vitriolic acid	Marine acid	Marine acid	Acid of ſugar	Acid of lemon	Marine acid	4
f ſugar of	Vitriolic acid	Acid of tartar	Vitriolic acid	Nitrous acid	Vitriolic acid	Acid of ſugar of milk	Vitriolic acid	Phoſphoric acid		5
e acid	Acid of ſugar	Phoſphoric acid	Acid of tartar	Acid of fat	Acid of tartar	Nitrous acid	Nitrous acid	Acid of tartar		6
s acid	Arſenical acid	Vitriolic acid	Nitrous acid	Acid of tartar	Nitrous acid	Acid of fat	Acid of tartar	Fluor acid		7
f fat	Phoſphoric acid	Acid of fat	Acid of fat	Phoſphoric acid	Acid of fat	Acid of ſorrel	Acid of ſorrel	Marine acid		8
oric acid	Nitrous acid	Marine acid	Phoſphoric acid	Acid of ſorrel	Phoſphoric acid	Acid of tartar	Acid of ſugar of milk	Vitriolic acid		9
ical acid	Acid of amber	Nitrous acid	Fluor acid	Fluor acid	Fluor acid	Phoſphoric acid	Phoſphoric acid	Nitrous acid		10
f ſorrel	Acid of ſorrel	Fluor acid	Acid of ſugar of milk	Acid of ſugar of milk	Acid of ſugar of milk	Acid of lemon	Acid of lemon	Acid of ſugar of milk		11
acid	Fluor acid	Acid of ſugar of milk	Acid of amber	Acid of amber	Acid of amber	Acid of amber	Acid of amber	Acid of amber		12
f amber	Acid of ſugar of milk	Acid of amber	Acid of lemon	Acid of lemon	Acid of lemon	Fluor acid	Fluor acid	Acid of fat		13
f lemon	Acid of lemon	Acid of lemon	Acid of ants	Acid of ants	Acid of ants	Arſenical acid	Arſenical acid	Arſenical acid		14
f ants	Acid of ants	Acid ot ants	Acid of milk	Acid of milk	Acid of milk	Acid of ants	Acid of ants	Acid of ants		15
f milk	Acid of milk	Acid of milk	Acetous acid	Arſenical acid	Acetous acid	Acid of milk	Acid of milk	Acid of milk		16
us acid	Acetous acid	Acetous acid	Arſenical acid	Acetous acid	Arſenical acid	Acetous acid	Acetous acid	Acetous acid		17
f borax	Acid of borax		Acid of borax		Acid of borax	Acid of borax	Acid of borax			18
f Pruſſian	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	Acid of Pruſſian blue	19
l acid		Aerial acid	Aerial acid		Aerial acid	Aerial acid	Aerial acid	Aerial acid		20
	Fixed alkali								Fixed alkali	21
	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali			Volatile alkali	22
										23
				Unctuous oils						24
										25
										26
										27
										28
Dry Way.										29
				Water					Water	30
	Tin	Bismuth	Nickle	Arsenic	Cobalt	Zinc	Antimony	Manganese	Siderite	31
e	Zinc	Lead	Iron	Nickle	Iron	Copper	Iron	Copper	Cobalt	32
lt	Mercury	Silver	Cobalt	Cobalt	Nickle	Antimony	Copper	Iron	Nickle	33
ganeſe	Copper	Gold	Arſenic	Copper	Arſenic	Tin	Tin	Gold	Iron	34
ic	Antimony	Mercury	Copper	Iron	Copper	Mercury	Lead	Silver	Manganeſe	35
er	Gold	Antimony	Gold	Silver	Gold	Silver	Nickle	Tin		36
	Silver	Tin	Tin	Tin	Platina	Gold	Silver			37
	Lead	Copper	Antimony	Lead	Tin	Cobalt	Biſmuth			38
	Iron	Platina	Platina	Gold	Antimony	Arſenic	Zinc			39
mony	Manganeſe	Nickle	Biſmuth	Platina	Zinc	Platina	Gold			40
na	Nickle	Iron	Lead	Zinc		Biſmuth	Platina			41
th	Arſenic	Zinc	Silver	Antimony		Lead	Mercury			42
	Platina		Zinc			Nickle	Arſenic			43
ury	Biſmuth					Iron	Cobalt			44
	Cobalt									45
										46
e liver of ſul-	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur	Saline liver of ſulphur		Saline liver of ſulphur	Saline liver of ſulphur		47
ur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur		Sulphur			48
										49
										50

TTRACTIONS.

No. I.

12	13	14	15	16	17	18	19	20	
of Tartar	Acid of Sorrel	Acid of Lemon	Acid of Benzoin	Acid of Amber	Acid of Sugar of Milk	Acetous Acid distilled	Acid of Milk	Acid of Ants	1
	Lime	Lime	Lime	Pure ponderous earth	Lime	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	2
ponderous	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Lime	Pure ponderous earth	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	3
magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure magneſia	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	4
vegetable al-	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	5
foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Lime	Lime	Lime	6
volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure magneſia	Pure magneſia	Pure magneſia	7
clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	8
of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	9
of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	10
of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	Calx of manganeſe	11
of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	12
of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	13
of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	14
of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	15
of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	16
of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	Calx of biſmuth	17
of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	18
of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	Calx of arſenic	19
of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	20
of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	Calx of ſilver	21
of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	22
of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	23
er	Water	Water	Water	Water	Water	Water	Water	Water	24
t of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	25
giſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	Phlogiſton	26
									27
									28
									29
									30
									31
			Lime	Pure ponderous earth	Lime	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	32
			Pure ponderous earth	Lime	Pure ponderous earth	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	33
			Pure magneſia	Pure magneſia	Pure magneſia	Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	34
			Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Lime	Lime	Lime	35
			Pure foſſil alkali	Pure foſſil alkali	Pure foſſil alkali	Pure magneſia	Pure magneſia	Pure magneſia	36
			Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	37
			Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	38
			Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	39
									40
									41
									42
									43
									44
									45
									46
									47
									48
									49
									50

NOTES

ON THE

PRECEDING DISSERTATION.

P. 4.] CONCERNING theſe admirable experiments of M. de Morveau, we have a very acute and pertinent obſervation by an author, frequently ſuperficial. He remarks, that there is a ſource of error in them of which M. de Morveau was not aware, for the inferior ſurface of the highly poliſhed plates, which are brought into contact with the mercury, being more or leſs readily diſſolved by it, according to the nature of the metal, will acquire an unequal addition of matter; and hence the difference in the weights, neceſſary to ſeparate the laminæ from the ſurface of the mercury, may ariſe, not from any difference of attractive power, but from inequality of maſs. (Fourcroy, Leçons Elem. Diſſ. ſur les Affinit.).

P. 32.] THE ſentence beginning in l. 11. would be clearer, if placed in the following manner:

"In the firſt place, we remark that a portion of phlogiſton flies off in the inflammable air," *&c.*

P. 47. l. 1. *&c.*] M. QUATREMERE D'ISJONVAL affirms, (*Collection de Memoires, Paris* 1784, p. 219. *&c.*) that when ſolutions of muriated magneſia and muriated lime, and likewiſe of vitriolated volatile alkali and vitriolated magneſia, are mixed together, the precipitation which takes place, is without decompoſition, and the effect of the ſtrong attraction of one of the compounds for water. But the exceſſive ignorance this author betrays of the moſt common obſervations in chemiſtry, (for he affirms, that when nitrated lime and vitriolated tartar are mixed together, the latter ſalt is precipitated) ſhews that his opinion is not worthy of the ſlighteſt attention.

IT is more ſurpriſing that Mr Morveau, the tranſlator and correſpondent of Bergman, and, unqueſtionably, one of the moſt philoſophic chemiſts in France, ſhould put the following queſtion, five years after it had been ſolved by our author, (N. Act. Upſal, V. III. 1775.) " How does it happen that two ſalts, which " when ſeparate have a ſufficient quantity of water " for their ſolution, ſhould, upon mixture, immediate-" ly yield cryſtals, as if the water had been attracted " by ſpirit of wine? This a *totally new* queſtion," *&c.* (l. c. p. 221.).

P. 65. l. 20.] THE words *of the ſubſtances* may be ſtruck out without injuring the ſenſe; and the omiſſion would make the ſentence run ſmoother.

P. 77.] **Neither** do the phænomena which attend the combuſtion of ſulphur, nor others of the ſame nature, admit of rational explanation upon any principles hitherto known, unleſs we adopt Mr Cavendiſh's diſcovery concerning the conſtituent parts of water. The experiments of that excellent chemiſt, in my opinion, lead to more ſpeculations, and promiſe the ſolution of more phænomena, than any which have been publiſhed ſince the fundamental diſcovery of Dr Black. But I ſhall have occaſion to conſider them more particularly below.

P. 89. 32.] **This** conjecture of the author's would ſeem to be erroneous, for Mr Wiegleb (Crell's Neueſt Entdeck. Th. 11. p. 14. 1783.) relates ſome experiments, from which it evidently appears, that fixed vegetable alkali has a ſtronger attraction for vitriolic acid, *viâ ſiccâ*, than the heavy earth. ℥ſs of the heavy ſpar being expoſed to a ſtrong heat in a crucible, with ʒvi of ſalt of tartar, was decompoſed all but 28 grains. Mr Wiegleb adds, that this is a much eaſier proceſs than that of Scheele and Bergman. Dr Withering has ſome experiments (Phil. Tr. v. lxxiv. p. 304. 1784.) that exactly coincide with theſe, but Mr Wiegleb's ſeem to be of an earlier date. No mention is made by either of foſſil alkali; but it may be ſuppoſed to agree with the vegetable. I have arranged theſe ſubſtances accordingly, but have drawn no line between them, ſince it is not abſolutely certain,

tain (though I have little doubt of it) that pure fixed alkali will effect this change. That the aerial acid comes into action in the above mentioned experiment, there can be no doubt, for Mr Wiegleb makes expreſs mention of an effervescence.

P. 96. l. 2.] WHENEVER the author diſpoſes ſubſtances by conjecture or analogy, he takes care to inform his reader. As he therefore ſpeaks poſitively in the preſent paragraph, it is to be concluded that he ſpeaks from experiment. Dr Withering, however, (l. c.) affirms the contrary with great confidence. I have ſo often, ſays he, repeated theſe experiments, to ſatisfy myſelf and others, that I am perſuaded the terra ponderoſa cauſtica ought to be placed below the alkalis, exceptin the column appropriated to the vitriolic acid. Mr Kirwan, confiding in the accuracy of Bergman, aſks, Whether a deception may not have ariſen from the abſorption of an exceſs of acid, by the alkalis that were added? It is likewiſe to be remembered, that when Dr Withering employed pure vegetable alkali, he obtained a precipitate, ſoluble neither in water nor acids, *viz.* a combination of the alkali and earth. The ſame precipitate likewiſe appeared when an aqueous ſolution of pure terra ponderoſa was added to pure vegetable or foſſil alkali, but none when it was added to pure volatile alkali. Theſe precipitates are undoubtedly well worthy of farther examination. It muſt ſurely, *a priori,*

priori, ſeem juſt as extraordinary, that volatile alkali ſhould throw down the heavy earth, as that the fixed alkalis ſhould be precipitated by it. Meanwhile, till this matter is thoroughly cleared up, I have placed a note of interrogation after the heavy earth, in the table of words.

Ibid. note.] MR CAVENDISH found that the water proceeding from the deflagration of inflammable and dephlogiſticated air, is always impregnated with nitrous acid, whenever thoſe airs are exploded in ſuch a proportion, that the burnt air is not much phlogiſticated, from whatever ſubſtance the dephlogiſticated air may have been procured. But if the proportion be ſuch, that the burnt air is almoſt entirely phlogiſticated, the condenſed liquor is not at all acid, but ſeems pure water, without any addition whatever; and when they are mixed in this proportion, very little air remains, almoſt all being condenſed. Theſe phænomena may be explained, by ſuppoſing, either that nitrous acid, in ſmall proportion, is a conſtituent part of dephlogiſticated air, or that phlogiſticated air is nitrous acid, with a larger proportion of phlogiſton than nitrous air. To the latter ſuppoſition Mr Cavendiſh evidently inclines, and obſerves, that, in conformity to it, part of the phlogiſticated air, with which the vital is debaſed, is, in his experiment, converted into nitrous acid, by the ſtrong affinity of the latter to phlogiſton. As a confirmation of his ſuppoſition, he remarks, that when nitre is deflagrated with charcoal, the acid is almoſt entirely converted into this kind of air.

THIS acute conjecture points to the origin of nitrous acid, a diſcovery which, ſince chemiſts have been ſo converſant with elaſtic fluids, has always ſeemed to be near at hand, though it has conſtantly eluded their graſp. For if it be true, it is reaſonable to imagine that Nature has ſome proceſs by which ſhe diſengages the acid, and perhaps, in the variety of her operations, another by which ſhe again combines it. At all events, the ſubject is worth proſecuting. And it would ſeem adviſable to expoſe nitrous air to various ſubſtances, by which we may expect to communicate phlogiſton to it; for although this has been already done, as by expoſing it to liver of ſulphur, and the reſult has been ſuch as ſeems rather to favour Mr Cavendiſh's hypotheſis, yet we are not enough acquainted with it to draw a certain concluſion.

ANOTHER method might be, to obſerve the effect of vital upon phlogiſticated air, under as many different circumſtances as can be imagined. Some experiments on inflammable air, to be mentioned hereafter, would ſeem to afford encouragement for ſuch an inveſtigation. Theſe elaſtic fluids are indeed conſtantly preſent together in the atmoſphere, but that is a ſituation not calculated for ſuch obſervations. Might not the electric fluid be of great ſervice here alſo?

We are beſides indebted to Mr Becker of Magdeburg, for ſome recent obſervations on the origin of the nitrous acid. In a pamphlet, (Entdecktes Saltpeter-ſauer in den Animaliſchen Auſleerungen, Deſſau. 1783), he rejects both the ancient and modern opinions concerning the generation of this acid, either as palpably falſe, or as unſupported by any adequate proof. He aſſerts, that the putrid fermentation is not at all neceſſary to its production. He found (Experiment I.) nitrous acid in cows urine, which had been expoſed for eight days to the ſun. He mixed ſome of the ſoakings of a dunghill with a ley of burnt ſheeps dung, and chalk in powder. The mixture began to ferment on the following day, and on the fourth, the internal commotion having ceaſed, he found at the bottom of the phial, regular cryſtals of priſmatic nitre.

In a ſupplement to this publication, he tells us that he has found the full ſolution of the problem concerning the generation of nitre, and that the acid is not to be ſought in the air, but in the vegetable kingdom, *by means of the excretions of animals*. "I found further, ſays he, that this kingdom affords not only the common fixed alkaline ſalt, but alſo a fixed-alkaline-animal neutral ſalt, which appeared on lixiviation, notwithſtanding the dung was dried and burnt. It is truly ſurpriſing, that during the burning of the ſtraw or dung, its alkali, together with the acid contained in the dung, ſhould not be deſtroyed by the

proceſs,

proceſs, but ſhould combine with each other. The farther I proceeded, the more I diſcovered. On examining the earth of ſtables and cow-houſes, I found that its lixivium yielded priſmatic nitre, while that of the dung would only afford ſmall cryſtals, which required an addition of nitre, in order to be reduced to a priſmatic form. Moreover, I can extract nitre at pleaſure, in the courſe of three days, from the earth of ſtables and cow-houſes, by uſing for ſaturation well purified potaſhes."

THESE experiments do not, indeed, ſhew the conſtituent parts of nitrous acid, but they may ſerve to warn us againſt falſe theories. I am ſorry that I can give no account of the experiments and opinions of Mr Thouvenel, the ſucceſsful candidate for the prize offered by the French Academy, having never yet been able to obtain a peruſal of his diſſertation.

P. 111. l. 15.] IT may be worth while to examine into this matter a little more narrowly. The difference between neutral ſalts containing phlogiſticated and dephlogiſticated acids, is very ſtriking, in many inſtances. Should we even admit, that the alkali contains a portion of the inflammable principle, and communicates it to the acid, there muſt ſtill be a deficiency, *i. e.* leſs phlogiſton than in common ſalt, unleſs it be ſupplied from ſome other quarter; and we might expect a ſenſible difference. It is not to be expected, from what is ſaid of the attraction of vital air for phlogiſton, that the aerial acid (ſuppoſing it to conſiſt of theſe two ſubſtances) of the alkali will be decompoſed by the dephlogiſticated muriatic acid. I wiſh, however, that the experiment were made, with a view to the examination of the elaſtic fluid.

SINCE this part of the note was written, I have ſeen a paper on the dephlogiſticated marine acid, by Mr Bertholet, (Journ. de Phyſique, Mai 1785.) who directed his attention, in ſome meaſure, to this very object. He boiled in an air-apparatus a mixture of foſſil alkali and dephlogiſticated marine acid, and found that the diſengaged elaſtic fluid was at firſt aerial acid with common air; next, air of a purer kind; and, laſt of all, aerial acid again. From calcareous earth, *no aerial acid is diſengaged, but only atmoſpheric air, which gradually becomes more and more pure, and is at laſt very pure dephlogiſticated air.* This laſt experiment looks very like a confirmation of my conjecture, that the dephlogiſticated acid gets phlogiſton from the elaſtic fluid. But Mr Bertholet has, by no means, ſufficiently inveſtigated the problem, though what he obſerved may ſerve ſtill further to ſhew that it is worthy of inveſtigation.

THE atmoſpheric air, in the firſt experiment, was beforehand contained in the veſſels. Whence the vital air that appears afterwards proceeds, it is not eaſy to tell. Can it come from the decompoſition of water, which perhaps the ſtrong attraction of the dephlogiſticated acid may aſſiſt in accompliſhing in a gentle heat?

Mr Bertholet himſelf, conformably with the new French hypotheſis, deduces it from the dephlogiſticated muriatic acid.

The neutral ſalt, formed in this experiment, was exactly like common ſalt.

What he ſays of volatile alkali, is very obſcure. He perceived an effervesſcence, even when the alkali was cauſtic; and the elaſtic fluid was of a peculiar kind, and, as he thinks, is formed by the combination of volatile alkali, and the dephlogiſticated air yielded, according to his hypotheſis, by the acid.

Possibly the acid, by attracting the phlogiſton of the volatile alkali, may decompoſe part of it; and if ſo, the elaſtic fluid that is extricated will be the ſame as that which is obtained by the exploſion of fulminating gold, (Scheele on air and fire, Bergman Opuſc. vol. ii.); and the acid being thus reduced to common marine acid, will unite with the reſt of the volatile alkali, and form ſal ammoniac, which was the product obtained by Mr Bertholet.

P. 115. l. 11. 12 &c.] Mr Tillet, who has lately (Mem. Paris. *année* 1780.) examined the action of nitrous acid upon gold, in the circumſtances deſcribed by Mr Brandt, has been led to form an oppoſite opinion. He allows, that nitrous acid, under theſe circumſtances, does actually *attack* gold *in leaves, and in a ſtate of ductility*, but contends, that it does not really diſſolve it either wholly or in part, keeping it only mechanically ſuſpended. Whether he has brought any new experiments or arguments that prove his aſſertion ſatisfactorily, let the reader judge. He obſerves, and it was known before, 1. *That, if a little ſilver be added to nitrous acid containing gold, the latter metal will be precipitated.* The connection between mechanical ſuſpenſion and this effect, is not very obvious; but, if we ſuppoſe the gold to be diſſolved, then it may be ſaid, that the phlogiſton afforded by the ſilver is the cauſe of the precipitation; ſo that this phænomenon would appear to be rather unfavourable to the author's opinion, and ſo far unfavourable as to counterbalance all his other arguments.

2. GOLD *thus precipitated,* (1.) *notwithſtanding its tender and ſpongy ſtate, is not taken up by nitrous acid, however concentrated and aſſiſted by heat.* It certainly ſeems extraordinary, that metallic particles, diffuſed through the ſubſtance of another metal, ſhould be, in ſome meaſure, ſoluble; and yet, that theſe very particles, in a ſtate of equal tenuity, ſhould become inſoluble, when the other metal has been removed. But the fact, however remarkable, can ſcarce be thought concluſive. It is the oppoſite of that caſe, in which the particles of a body, eaſily ſoluble by themſelves, are yet prevented from being diſſolved, by being mixed with a large proportion of an inſoluble body.

3. MR TILLET *found, that all the gold was depoſited while the nitrous acid was paſſing through a filter of four folds of paper.* Mr Brandt obſerved, that the gold

was depoſited after the acid had ſtood ſome time, and alſo on agitation.

4. ON *examining a drop of the acid with the microſcope, Mr Tillet ſaw the particles of gold in their metallic ſtate, floating in it.* Can we ſuppoſe, that ſome particles are ſuſpended, while others are diſſolved? Or, may it be conjectured, that, as the noble calces eaſily recover their phlogiſton, a ſource of error might ariſe from the expoſure of the ſolution to the ſun's rays? That ſuch an accident might happen, appears from Mr Tillet's total ſilence with reſpect to this circumſtance.

THE Commiſſioners, moreover, (l. c. p. 615.) obſerve, that it appears from ſeveral of their experiments, that the pureſt nitrous acid takes up (*ſe charge avec*) a few particles of gold.

P. 120. l. 7. 8.] THIS opinion concerning the cauſe of the corroſive nature of certain metallic ſalts, has been adopted and confirmed by many experiments by Mr Bertholet, [Journal de Medecine, 1780, p. 50. The ſame eſſay was likewiſe ſince reprinted, with additions, in the Mem. Par. for 1780.] Among his experiments, the following ſeem the moſt concluſive: Corroſive ſublimate, expoſed to heat, (not a violent degree), with oil, is, for the moſt part, reduced. A piece of fleſh being put into a ſolution of this mercurial ſalt, a copious precipitation took place; the liquor now reddened ſyrup of violets, whereas it had before turned it green. The precipitate was calomel.

PRECIPITATES of corroſive ſublimate, whether with lime, or alkalis diſſolved in nitrous acid, without effervescence or red vapours.

MERCURY diſſolved in aqua regia yields corroſive ſublimate; whence, as well as from other conſiderations, the author concludes, that the muriatic acid exiſts in corroſive ſublimate, in a dephlogiſticated ſtate. He has ſince given (Journ. de Phyſ. Mai 1785.) a very beautiful and ſimple proof of the ſame poſition. By only adding the dephlogiſticated acid to a nitrous ſolution of mercury, he obtains corroſive ſublimate. Nitrous ſolutions of mercury become more corroſive, as they are more deprived of phlogiſton.

FROM theſe, and ſome other experiments, the author thinks himſelf fully entitled to conclude, that the corroſive quality of metallic ſalts depends on their attraction for phlogiſton.

P. 129.] NOTWITHSTANDING the ſtrong attraction of the acid of ſugar for lime, there are caſes in which it will not ſhow its preſence. We have an inſtance of this important practical obſervation in Mr Scheele's and our author's analyſis of the calculus. The former perceiving no precipitation to take place on the addition of acid of ſugar, immediately concluded, that there was no lime preſent; but the latter having often obſerved, that a third ſubſtance ſuperadded to two already united, inſtead of effecting a ſeparation, enters into cloſe combination with them, ſuſpected, that this might be the caſe here, eſpecially as he knew, that the ſaccharine acid contains an unctuous matter, though of great ſubtilty. And upon burning ſome calculus to aſhes, obtained a ſubſtance which exhibited the moſt unequivocal marks of calcareous earth. (Stockh. Tranſact. vol. xxxvii. p. 333.) Hence we learn, how deſirable it is in chemiſtry to be poſſeſſed of more than a ſingle teſt, as it is called, of different ſubſtances.

P. 139. l. 21.] THIS perſon probably is Mr Hermbſtadt of Berlin; for we have a paper by him on this ſubject in Crell's Neueſt. Entdeck. part 9. p.6. It is obvious to ſuſpect, that the vegetable acids of ſugar and tartar, at leaſt, and perhaps of vinegar, are, at bottom, one and the ſame, only modified by ſome addition, rather accidental than eſſential. This ſuſpicion is favoured, not only by a reſemblance in ſenſible qualities; but alſo, by the production of one or other of theſe acids, according to the different circumſtances of a body, as in the ſeveral ſtages of fermentation. But ſuch conſiderations are, by no means, fitted to decide any chemical queſtion; they can only ſerve to ſuggeſt proper experiments. Accordingly, Mr Hermbſtadt attempted ſuch as were likely to decide the queſtion: one part of acid of tartar, treated with four parts of nitrous acid, (of which the ſpecific gravity was to water as 41 : 28,) as in the preparation of ſaccharine acid, yielded ſome cryſtals like thoſe of this latter acid, but only in the proportion of $\frac{1}{16}$ in one experiment, and about $\frac{1}{9}$ in another.

BUT upon adding four ounces of ſmoking nitrous acid to ſix drachms of acid of tartar, and abſtracting it with a briſk fire, he obtained four drachms and two ſcruples of columnar cryſtals, which produced, in a great number of experiments, the ſame effects as the acid from ſugar, and, in many reſpects, different from that of tartar. Though ſuch numerous proofs of coincidence ſcarce leave any doubt, yet it is ſtrange, that Mr Hermbſtadt ſhould neglect what may be conſidered as the *experimentum crucis*, the precipitation of a ſolution of gypſum. He promiſed, indeed, more experiments; but I have not been able to find them, either in the continuation of Crell's Journal, or any other work. It is however to be remembered, that Bergman treated the acid of tartar with nitrous acid, without obtaining any acid of ſugar, [Opuſc. vol. i.] Nor is it to be forgotten, that two vegetable or animal acids are very frequently preſent in the ſame compound, as in the caſe of ſugar of milk and microcoſmic ſalt. But we can ſurely ſcarce ſuppoſe, that ſo large a proportion of acid of ſugar ſhould be accidentally preſent.

MR WESTRUMB, another very intelligent German chemiſt, obtained four drachms, two ſcruples of acid of ſugar, from an ounce of tartar, treated with nitrous acid. His method of proceeding is worth mentioning.

To an ounce of tartar, he added two ounces of weak nitrous acid, and diſſolved it by means of a gentle heat. The liquor was then expoſed to evaporation in the ſun's rays, and, in ſome days, he obſerved cryſtals of nitre formed, amounting to two drachms, five grains; when it would yield no more of theſe, two ounces of ſtrong nitrous acid were added to the acid and viſcid reſiduum; when the phial had ſtood a ſhort time, red vapours began to ariſe; the addition of ſtrong nitrous acid was repeated, as long as the liquor retained any viſcidity, or any red vapours aroſe, in which four ounces of nitrous acid were conſumed in all, and the quantity of ſaccharine acid obtained was four drachms, two ſcruples.

P. 158.] INSTEAD of obtaining phoſphoric acid by the tedious and waſteful method of combuſtion in the air, I ſhould think chemiſts would procure it by decompoſing phoſphorus with nitrous acid, as Mr Lavoiſier directs, Mem. Paris, *ann.* 1780, p. 349. & ſeq. Nothing is required to procure the acid in a ſtate of as great purity, as by combuſtion, and with the greateſt eaſe and expedition, but a prudent management of the fire.

P. 165.] THE proceſſes mentioned in this page, ſuggeſt what has been ſought by ſo many chemiſts, an unexceptionable method of preparing Pruſſian or phlogiſticated alkali; all that remains to be done after the acid has been once obtained, is to ſaturate it with an alkali or with an abſorbent earth, which, if we may judge from ſeveral inſtances mentioned in the text, ſeems to anſwer equally well. But a ſhorter proceſs occurred, in conſequence of the diſcovery of the nature of phlogiſticated alkali, to Mr Scheele, and much about the ſame time to Mr Weſtrumb.

The method of the latter is as follows: he ſaturates pure vegetable alkali by frequently boiling it with well-waſhed Pruſſian blue. He then boils the filtered liquor with white lead, in order to ſeparate any ſulphureous or phlogiſtic particles that may happen to adhere to it. He then adds vinegar, which when it has been diſtilled in tin-veſſels, occaſions the precipitation of a white matter in great abundance; but not a particle of blue is ſeen to fall. He then, in conformity with Scopoli's advice, expoſes the liquor to the ſun's rays, and keeps it in that ſituation as long as any red precipitate is obſerved to ſeparate. Upon this the lixivium is filtered, and then mixed with a double quantity of highly rectified ſpirit of wine, which throws down the proper ſalt of the *lixivium ſanguinis* in the form of ſhining flocculi; they are to be ſeparated by means of the filter, and all the ſaline matter ſoluble in ſpirit of wine is to be extracted by that menſtruum. The ſolution of the ſalt in water, is of a bright yellow colour; does not ſhew the leaſt veſtige of iron upon the addition of an acid; precipitates that metal of a beautiful blue colour, copper red, *&c.*

Mr Scheele's method is far leſs complicated. He extracts, as before, Pruſſian blue, with perfectly cauſtic fixed alkali, and then mixing highly rectified ſpirit of wine with the filtered liquor, he obtains the ſalt in the form of flocculi. Mr Scheele adds, that he is thoroughly convinced of the inefficacy of every other method of purifying the *lixivium ſanguinis*; for if the yellow ſolution be properly boiled with muriatic or vitriolic acid, Pruſſian blue will always be ſeparated. The ſalt obtained by the proceſs juſt deſcribed, is not liable to alteration in the open air; for the iron holds the tinging acid in cloſer union with the alkali, and fixes it ſo that it cannot be diſlodged by the aerial acid, which otherwiſe would happen, was it not combined with iron or ſome other metal in the tinging lixivium.

P. 187. § 42. Magneſia.] Mr Butini of Geneva (*Nouv. Obſerv. et Recherch. ſur la Magneſie. A Geneve.*) having lately publiſhed ſeveral curious obſervations on magneſia, which have not, as far as I know, been laid before the Engliſh reader, I am tempted to give a ſhort account of them, although they are not ſo immediately connected with the doctrine of attractions. He was not acquainted with the diſſertation of Bergman on this earth[1]; but he nearly agrees with him, in ſaying that an ounce of diſtilled water is capable of diſſolving a grain, or at moſt $1\frac{1}{2}$ grain of magneſia, whereas the ſame quantity of aerated water takes up thirteen grains. He found that magneſia does not at firſt diſſolve in aerated water, but decompoſes it by attracting the fixed air; when once ſaturated, it diſſolves without decompoſition; in its ordinary ſtate, therefore, this earth is not ſaturated with aerial acid, the alkali uſed for its precipitation not ſupplying it with a ſufficient quantity. Mr Butini determines by exact experiments, that ſaturated magneſia contains $\frac{1}{10}$ of the aerial acid, more than in its ordinary ſtate. The ſolution in aerated water in the proportion of 1 : 64, becomes turbid in a temperature of 158° of Fahrenheit. But one of the moſt remarkable among his obſervations, is, that water may be over-ſaturated with magneſia, and yet paſs through the filter, and ſeem clear. Such a ſolution is obtained by immediately filtering the water in which Epſom ſalt has been decompoſed; if it be heated to 68° Fahrenheit, (which may be done in the palm of the hand), it lets fall its earth, which is rediſſolved when the liquor cools to about 59°. This is a very amuſing experiment.

The ſpontaneous cryſtallization is alſo a new and curious phænomenon. It will abandon the water, even when that is not ſaturated, in order to arrange its integrant parts into regular forms. The cryſtals are hemiſpherical *matrices*, conſiſting of needles, from the length of half a line, to that of five or ſix lines,

which

which are tranſparent hexaedral priſms, terminated by an hexagonal plane.

When it is made to cryſtallize in a temperature of 59°—62°, two kinds of cryſtals are formed, *viz.* groups of needles and ſolitary *blocks*, of which the ſhape is not exactly defined, though it is to be referred to that of an hexaedral priſm, terminated by an hexagonal pyramid. In a heat of 39° to 41°, nothing but blocks appear; and again from the 73° to the 77°, the needles only are formed.

By repeated or violent calcination, magneſia loſes its property of eaſy ſolubility in acids. Its particles, without acquiring a greater degree of mutual coheſion, gain a remarkable hardneſs, whence they become capable of ſcratching ſteel, &c. Water does not diſſolve above $\frac{1}{9793}$ of calcined magneſia, nor does the ſolution yield any cryſtals. During calcination, this earth emits a phoſphoric light, and adheres with great tenacity to cold bodies; it alſo preſents that appearance of fluidity, which is remarked in gypſum. Calcined magneſia, expoſed to an atmoſphere of aerial acid, or left in a veſſel covered only with a piece of looſe paper, does not recover its fixed air.

Neutral ſalts heighten the ſolvent power of water, while alkalis diminiſh it.

To theſe experiments of Mr Butini, let me be allowed to ſubjoin ſome of another author, not leſs remarkable, though they relate to another part of the chemical hiſtory of magneſia, *viz.* its combination with acids.

Mr Quatremere D'Isjonval (Coll. des Memoires, p. 207.) gives an account of his having obtained permanent compounds, with magneſia and nitrous acid; and what is more extraordinary ſtill, with muriatic acid likewiſe. To obtain this effect with the firſt, he precipitated purified Epſom ſalt, diſſolved in cold water, with fixed vegetable alkali; he then ſaturated the magneſia with pure nitrous acid, and evaporated the ſolution, which at firſt yielded nitre, on account of ſome alkali carried down by the precipitate. After this was ſeparated, he rediſſolved the ſaline magma, and evaporated it again: Theſe operations he repeated two or three times, till ſome rudiments of cryſtals appeared, which being rediſſolved, afforded, on evaporation, cryſtals that had a ſtronger tendency to effloreſce than deliquiate, even in a moiſt place. They have the form of four-ſided priſms, truncated acutely. With muriatic acid he proceeds much in the ſame manner, taking care to ſaturate the acid completely.

He ſubjoins two cautions of importance for the more certain and ſpeedy production of theſe cryſtals: 1. That not above half the magneſia ſhould be precipitated, for he is afraid of the preſence of calcareous earth; and 2. That the magneſia ſhould be diſſolved in the acid, while it is yet in the tender form of a precipitate.

I was unwilling to with-hold theſe curious obſervations of a chemiſt who had carried away the prize, when Bergman was his competitor; but, whatever authority this may add to his name, I think that he who ſhall peruſe his writings, will be careful how he gives entire credit to his aſſertions, before he has repeated his experiments, though it muſt be confeſſed, that they receive ſome authenticity from a letter of Mr de Morveau (p. 222.) to whom Mr D'Isjonval ſent ſpecimens of his cryſtals.

P. 198. *paragraph* B.]. I MUST confeſs myſelf ignorant of any good reaſon for believing *phlogiſticated*, *foul*, or *corrupted* air, to be a modification of vital air. Mr Kirwan's reaſons for ſuppoſing it to be aerial acid, combined with more phlogiſton, convey to me no ſort of conviction. Mr Cavendiſh has thrown a ray of light upon this obſcure ſubſtance, as I have already mentioned, and unleſs his rational conjecture ſhould be ripened into a diſcovery, it is better to own our entire ignorance of the nature of this elaſtic fluid, than to content ourſelves with any of the explanations that have yet been offered.

P. 199. & ſeq. *paragraph B.*]. THE connection between nitrous acid and vital air now begins to appear in a very different light. To ſuppoſe that theſe two ſubſtances were but modifications of one and the ſame, was both natural and allowable, when vital air was firſt procured from nitre; but when it appeared, in the progreſs of enquiry, that ſo many other bodies, free from all ſuſpicion of any mixture of nitrous acid, were found to yield the ſame fluid, the opinion could be no longer tenable, nor is it, by any means, conformable to the uſual ſeverity of the author's logic. The experiments of Mr Cavendiſh and Mr Watt ſhew, that the common office of nitrous acid and other ſubſtances, is merely to dephlogiſticate water. The latter, who made an attempt to recover the nitrous acid, found, upon procuring vital air from this acid and earths, that, however thoroughly the acid and earth might be dephlogiſticated, the acid always became highly phlogiſticated after the proceſs. (Ph. Tr. vol. lxxiv. p. 338.). He found, moreover, in one experiment, that thirty-ſix ounces meaſure of vital air were produced, and only five grains of weak nitrous acid miſſing; and in another, thirty-four grains weight of the ſame air were produced, with the loſs of only two grains of *real* acid, p. 343.

FURTHER, when vital air is obtained from vitriolic ſalts, vitriolic acid air appears, at the ſame time, even when the ſalts are not known to contain any phlogiſtic matter, p. 344.

P. 208. & ſeq. *paragraph C.*] IT is now no longer probable, either that Mr Kirwan's or Mr Scheele's opinion will be confirmed. Both muſt give way to the diſcovery of Mr Cavendiſh, concerning the conſtituent parts of water. By ſome experiments made in the ſummer of 1781, and read before the Royal Society in 1784, he found, that, upon firing together inflammable and vital air in cloſe veſſels, they were condenſed into water. Other chemiſts, both at home and abroad, have now amply confirmed this unexpected obſervation, as Dr Prieſtley, S. Laudriani at Milan, and Mr Lavoiſier at Paris, who has uſed very large quantities in his experiments, but has ſhamefully attempted to appropriate the diſcovery to himſelf; and he is accordingly mentioned in many foreign journals as the firſt diſcoverer. Dr Prieſtley found, that after inflammable and vital air had been deflagrated together, and the veſſel had cooled to the temperature of the atmoſphere, as much mercury or water, in whichever of theſe liquids the mouth was immerſed, entered, as was ſufficient to fill it within $\frac{1}{200}$ part of its contents: moreover, when the moiſture adhering to the glaſs was wiped off with a piece of ſponge paper, firſt carefully weighed, it was found exactly, or very nearly, equal to the airs employed. (Mr Watt, Ph. Tranſ. vol. lxxiv. p. 332.). This diſcovery is ſo much the more to be admired, as no hints had been thrown out by any other author which could lead to it, nor could it have been ſurmiſed by any analogical reaſoning. It promiſes, however, to furniſh explanations of many of the obſcureſt operations, both in art and nature. Thus the generation of vital air, the diſappearance of vital and nitrous air, when mixed together, the production of vital air by vegetables, the diminution of the air in the combuſtion of ſulphur, phoſphorus, &c. are now no longer phænomena that require, for their explanation, hypotheſes uncountenanced or contradicted by experiments. But Mr Cavendiſh's diſcovery leads to much wider views. It ſuggeſts new experiments on the increaſe of weight of calcined metals, a problem ſtill remaining to be ſolved, notwithſtanding ſo many late attempts. The firſt object of thoſe who ſhall now labour on this ſubject, ſhould be to aſcertain, whether a quantity of water, equal to the difference of weight, is generated during calcination. The general principle is equally applicable to volcanos and to ſtatical phyſiology; for it is now obvious to ſuſpect that the exhalation from the lungs is not thrown off in that form by animals, but rather generated by the mixture of the dephlogiſticated part of the common air with phlogiſton. But this is not the proper place to indulge in ſuch ſpeculations.

To offer any arguments againſt Mr Scheele's doctrine of the compoſition of heat, would be now ſuperfluous, ſince Mr Kirwan (Notes to the Treatiſe on Air and Fire) and Fontana (Opuſc. Litt. à S. Adolph. Murray) have abundantly confuted it. Bergman, himſelf, notwithſtanding he has adapted ſeveral explanations to it, ſeems to acknowledge at laſt, that it is liable to inſurmountable objections. One alone is ſufficient: that loſs of weight, which muſt enſue if the vital air and phlogiſton paſs off through the veſſels in the form of heat, is not obſerved. But it is a proof of Mr Scheele's acuteneſs, that he firſt perceived the neceſſity of ſome ſubſtance containing vital air and phlogiſton in ſo many chemical experiments.

Mr Kirwan's explanation, is equally inadmiſſible; for Mr Cavendiſh has ſhewn, in the moſt ſatisfactory manner, that no fixed air is generated by the mixture of nitrous and vital air, any more than in the exploſion of inflammable air; or at leaſt, if any be generated, it is ſo ſmall a quantity, "as to elude the "niceſt teſt we have." (Ph. Tr. vol. lxxiv. p. 121. 122.; and 172. 173.)

P. 211. l. 3. and 4.] Mr Senebier (Recherches ſur l'air inflammable) has found that inflammable air actually does change vital air in a length of time. By keeping theſe ſubſtances over water, he obſerved that a diminution took place, and that the reſiduum did not undergo any alteration on the addition of nitrous air. From what Mr Kirwan ſays, (Ph. Tr. vol. lxxiv. p. 168.) it ſeems that Dr Prieſtley has made obſervations to the ſame purport; for he tells us, that the Doctor has diſcovered, ſince his laſt publication, that inflammable and dephlogiſticated air will unite.

P. 223. l. 5. & ſeq.] Precipitate *per ſe*, and red precipitate, are ſoluble in marine acid, and during the ſolution, nothing is diſengaged, but a great heat is produced, as in the ſlaking of quicklime; the ſalt which is obtained by reducing the ſolution to cryſtals, is corroſive ſublimate.

THIS obſervation does not coincide with the experiment of Bergman, who affirms, that calcined mercury is reduced by digeſtion in muriatic acid. I cannot gueſs how he could have made his experiment; for whenever I have added precipitate *per ſe* to muriatic acid, I have always obſerved ſolution to take place with the production of much heat, and have obtained cryſtals of corroſive ſublimate on refrigeration. It is true indeed, that when red precipitate is employed, a black powder, conſiſting of mercury, ſeparates; but this mercury is not any of the calx revivified; it ſeparates during the time of ſolution, becauſe the muriatic diſſolves no mercury *that is not combined with vital air*; and this mercury happened to be mixed with the calx; ſo, if we take notice of what paſſes in the preparation of red precipitate, it will be ſeen that firſt nitrous air, and afterwards red precipitate paſs over, long before the mercury riſes. May not Bergman have uſed this precipitate, and thus been led into a miſtake? He knew not how to explain the reduction. Mr Kirwan (Phil. Tranſ. vol. lxxiv. p. 159.) ſays that the reduction is owing to the expulſion of the fixed air from the mercurial calx; which fixed air, at the moment of its expulſion, is decompoſed, leaving its phlogiſton to the mercury, which is thereby revived. But this explanation is inadmiſſible, ſince no reduction takes place, as I have already obſerved. (*Pelletier J. de Phyſ. Mai*, 1785.)

P. 253. l. 11. & ſeq.] DR PRIESTLEY ſays, that the iron is *ſuperphlogiſticated*, and has lately aſſured us, [Phil. Tranſ. vol. lxxiii.] that he has frequently repeated the experiment with the ſame reſult. I fear, that neither Prieſtley nor Bergman have examined the ſtate of the iron, otherwiſe than ſuperficially. Perhaps, on a more accurate examination, ſomething might appear that would lead to an explanation of the phænomenon.

P. 257. l. 4. & ſeq.] CRELL adviſes (Chem. Annal. St. i. p. 94.) to uſe in this experiment another equal and ſimilar veſſel, containing a quantity of water A, of equal weight, and at the ſame temperature (32° Fahr.) with the ice B; let the two veſſels, he adds, be placed near one another, and obſerve how long a time A requires to attain the temperature of the room. Moreover, obſerve how long a time B requires, *1ſt*, to melt, and, *2d*, to attain the temperature of the room. Next, multiply the degree of heat acquired by A, by the time B *1ſt*, took to melt, and, *2d*, to attain the temperature of the atmoſphere. Then, ſuppoſing the degrees of the thermometer to correſpond to equal acceſſions of the matter of heat, we may ſay, as much heat, (*i. e.* ſo many particles of fire), as is ſufficient to raiſe the thermometer to a certain heat, has ſuch a weight.

I HAVE heard, that one of thoſe Philoſophers who believe heat to be merely a quality, has made the experiment propoſed by Bergman, with this ſtrange reſult, that, during the melting of ice, a diminution of *abſolute* gravity takes place. If my information be right, I ſhould think ſuch a concluſion could prove nothing, but either the difficulty of making the experiment, without ſuffering ſome of the vapours to eſcape, or elſe the careleſsneſs of the obſerver.

P. 258. 259. 260.] MR LAVOISIER and De la Place have lately given the following table of ſpecific heats :

Common water,	1,
Sheet iron,	0,109985
Glaſs without lead, or cryſtal,	0,1929
Mercury,	0,029
Quicklime,	0,21689
Mixture of water and quicklime, in the proportion of 9 to 16,	0,334597
Oil of vitriol, (ſpec. grav. 1,87058,)	0,60362
Mixture of this oil with water, in the proportion of 4 to 5,	0,663102
Nitrous acid, (not ſmoking, ſpecific gravity, 1,29895,)	0,661391

Mixture

Mixture of this acid with quicklime, in the proportion of $9\frac{1}{3}$ to 1,	0,61895
Mixture of 1 part of nitre with 8 of water,	0,8167

The ingenious machine, contrived for the purpoſe of meaſuring the ſpecific heat of bodies, by theſe gentlemen, conſiſts principally of three cavities incloſed in one another. The outermoſt is filled with pounded ice, which is deſigned to intercept the influence of the atmoſphere upon the ice contained in the middle cavity. This latter is the real ſubject of the experiment, and the quantity of it melted by the bodies which are placed in the innermoſt cavity, gives the proportion of their ſpecific heats, which are evidently as the quantity of water obtained. But there is reaſon to fear leſt this ingenious and promiſing contrivance ſhould fail of anſwering the end propoſed; for Mr Wedgewood, who repeated ſome of the experiments, obtained the moſt oppoſite reſults, when the ſame body was heated to the ſame degree. His diſappointment aroſe chiefly from two cauſes; the firſt of which was the abſorption of the water by the pores of the ice; for, though the French Philoſophers pretend, that no error can ariſe from this cauſe, ſince the ice has already imbibed as much water as it can, yet it is obvious, that, as the preciſe degree of force with which the pounded ice is preſſed together cannot be adjuſted, more or leſs water will be ſucked up, as it forms a leſs or more compact body. The other difficulty ſeems ſtill more inſuperable. Mr Wedgewood found, that the two proceſſes of freezing and thawing were going on at the ſame time:—whether it be, that water in the ſtate of vapour is liable to freeze in a higher temperature than when liquid, as Mr Wedgewood conjectures, or the ordinary abſorption of heat by evaporation alone produces the effect, without any ſuch diſpoſition in the vapour. At all events, the preſent table, as well as thoſe which Mr Lavoiſier and De la Place promiſe, muſt be received with diffidence, till theſe impediments to accuracy be removed.

P. 263. *note.*] THE ſubſtance mentioned in this note, is called black wadd; by Da Coſta, *ochra friabilis nigra.* Its remarkable property of taking fire when mixed with oil, was firſt diſcovered accidentally at a painter's in Derby in 1752. Mr Wedgewood has lately (Phil. Tranſ. vol. lxxiii. p. 284.) publiſhed an analyſis of it. He finds it to conſiſt of inſoluble earth, chiefly micaceous, of lead, iron, and mangane≠ſe.

22 parts contain

of earth about	2
of lead	1
of iron	9½
of manganeſe	9½
	22

P. 268. 269.] **This** analyſis of charcoal differs exceedingly from that of Dr Prieſtley. He obtained not the leaſt particle of aerial acid from charcoal, when it had been perfectly well burned; but the whole quantity was converted, by means of burning lens, into inflammable air, except a very inconſiderable portion of aſhes. (Phil. Tranſ. vol. lxxiii. p. 411.)

P. 273.] **It** is now completely aſcertained by the experiments of Mr Hutchins at Hudſon's bay, that the freezing point of mercury correſponds to the 40th degree below 0 of Fahrenheit's thermometer; therefore the numbers in the text muſt be much reduced. The other data of Dr Crawford, *viz.* the converſion of vital into fixed or phlogiſticated air, have, by no means, the certainty of eſtabliſhed principles. We muſt now look for the origin of the heat, in the condenſation of vital air into water by phlogiſton. And thus we have Mr Cavendiſh's diſcovery extended to another of the moſt obſcure and familiar phænomena in nature.

P. 278.] **Before** the publication of Mr Cavendiſh's paper on air, (Phil. Tranſ. vol. lxxiv. p. 119. & ſeq.) Mr Kirwan ſeems to have almoſt ſucceeded in perſuading chemiſts, that fixed air is generated in phlogiſtic proceſſes, by the union of vital air with phlogiſton. Others had thrown it out long before as a probable ſuppoſition; but Mr Kirwan was, I think, the firſt, who, by collecting and arranging the numerous facts publiſhed by different authors, gave the opinion a great degree of plauſibility. Still, however, the complete proof, from unequivocal, analytical, and ſynthetical experiments, was wanting, and many of the moſt important caſes of phlogiſtication gave no ſort of countenance to the ſuppoſition.

Mr Cavendish, by a rigorous examination of the arguments, has fairly reduced them within a very narrow compaſs. In the firſt place, he juſtly obſerves, that all experiments, in which any organiſed bodies are employed, muſt be ſet aſide. He is inclined, likewiſe, to conſider the experiments with the electric ſpark as equivocal; being of opinion, that when turnſol is uſed, the aerial acid may ariſe from the burning of this vegetable matter; and, in the caſe of lime-water, from ſome impurity in the tube, or elſe from ſome inflammable matter in the lime.

There remain then but four caſes; the calcination of metals, the combuſtion of ſulphur or phoſphorus, the mixture of nitrous air, and the exploſion of inflammable with vital air.

Neither in the combuſtion of ſulphur and phoſphorus, nor in the exploſion of inflammable air, has any veſtige of aerial acid been perceived. That this is alſo the caſe in the mixture of nitrous air, Mr Cavendiſh has clearly ſhown, contrary to the general ſuppoſition, as I have already obſerved.

We have, therefore, left, for the ſupport of ſo important and extenſive a doctrine, only the calcination of metals: And in examining theſe experiments, made with care and cloſe veſſels, we do not find any evidence of the generation of fixed air. Mr Lavoiſier and Dr Prieſtley found none in the air in which they had formed their experiments; and, if it be ſaid, that the metallic calces abſorbed it, it is anſwered, that none has been extracted from calces ſo prepared. It is indeed true, that metallic calces prepared in open veſſels, or ſuch as have lain long expoſed to the atmoſphere, contain aerial acid; but here the atmoſphere is an evident ſource from which it might ariſe.

Mr Kirwan endeavours to remove theſe objections, by adducing ſeveral experiments, which ſhow, that aerial acid exiſts in very ſparing quantities in the atmoſphere, and by repreſenting it as improbable, that metals, during their calcination, ſhould attract it; becauſe lime, expoſed to a red heat ever ſo long, does not regain any. He inſiſts upon what he had formerly advanced, that the revivification of certain mercurial calces, and the production of vital air, is owing to the decompoſition of the aerial acid contained in the calces.

He thinks his opinion ſtrongly corroborated by an experiment of Mr Laſſone, in which filings of zinc having been digeſted with cauſtic alkali, an efferveſcence was obſerved on the addition of an acid; but Mr Cavendiſh ſuppoſes, that the efferveſcence aroſe, not from the expulſion of aerial acid from the alkali, but of inflammable air from the incompletely diſſolved zinc.

With reſpect to the experiment of Dr Prieſtley, mentioned in the text, Mr Cavendiſh relates an experiment, which ſeems to render it probable that the aerial acid proceeds from plumbago and other impurities contained in the iron: 500 grains of red precipitate, mixed with 1000 of iron filings, yielded 7800 grain meaſures of aerial acid; and 2400, partly of vital, and partly inflammable air. But 500 grains of the ſame red precipitate yielded 9200 of aerial acid, and 4200 of indifferent vital air; when they were mixed the plumbago and other impurities, which were the reſiduum of 1000 grains of iron filings, diſſolved in diluted vitriolic acid. Hence, as more aerial acid was produced when the red precipitate was mixed only with the impurities, than with the iron filings themſelves, it ſhould ſeem to follow, that its production was owing, not to the iron, but to the plumbago, which is known to contain a great deal of it. As, however, it was found, that the iron filings were mixed with $\frac{1}{13}$ of their weight of braſs, and, as more fixed air was produced, than the plumbago uſually contained in 1000 grains of iron can ſupply, (which is Mr Kirwan's objection), Mr Cavendiſh candidly acknowledges, that the experiment ought to be repeated in a more accurate matter.

Mr Kirwan, beſides, inſiſts upon the diminution of common acid by the electric ſpark, as the moſt convincing argument in favour of his opinion. An experiment, too, in which Dr Prieſtley having amalgamated lead with mercury, obtained aerial acid from the black powder into which the lead was converted, ſeems really favourable to him.

Such is the ſtate of a doctrine which ſo widely influences the theory of chemiſtry. Every one muſt acknowledge, that much ſtronger proofs muſt be adduced before it can be received as a fundamental propoſition. Now, when we know that vital air and phlogiſton conſtitute water, and that this will ſufficiently account for the diminution of the air, it is no longer a neceſſary hypotheſis: And this very diſcovery ſeems to give the opinion a general appearance of improbability, which the few facts that yet remain to countenance it, do not, by any means, outweigh; nay, it is probable, that theſe facts, as they are more narrowly ſcrutiniſed, will put on a different aſpect, as has already happened in the mixture of nitrous and vital or common air. May not ſome ſuch experiments as I have propoſed above, for exploring the nature of phlogiſticated air, ſerve to ſhow whether aerial acid is really a compound of phlogiſton and ſome other ſubſtance?

P. 285. Æther.] The reader will ſurely excuſe me if I digreſs a little from the ſubject of attractions, and the text of the author, in order to give him a ſhort account of ſome late experiments of Mr Scheele on this ſubſtance. They are to be found in the Stockholm Tranſactions, part iii. for the year 1782. Mr Scheele has not indeed yet been able fully to clear up the obſcure theory of the generation of æther; but his experiments have led him to ſome new views.

When vitriolic æther is prepared in a large retort, and a briſk heat is applied towards the laſt, volatile ſulphureous acid is obtained together with vinegar, but no veſtige of aerial acid:—when to an ounce of pounded mangane ſe, half that quantity of vitriolic acid, and an ounce of ſtrong ſpirit of wine was added, he got both vinegar and aerial acid, and found in the retort vitriolated manganeſe, without any exceſs of acid. He found that vitriolic and muriatic acids are conſtituent parts of their reſpective æthers, but in exceedingly ſmall proportions. Beſides zinc, antimony, and tin, by the intervention of which, it is well known that muriatic æther may be made, he obtained æther by a ſolution of biſmuth in aqua regia, evaporated to the thickneſs of a ſyrup, and of crocus martis (iron filings will not anſwer the purpoſe) in muriatic acid. He alſo obtained æther by ſaturating ſpirit of wine with fluor acid air, and adding manganeſe. No acetous æther is to be obtained by the proceſs of the Count de Lauraguais, notwithſtanding almoſt all chemical writers, except Poerner, have admitted that proceſs as an effectual one: Mr Scheele, however, found a way of preparing acetous æther, and that, in greater quantity than any other kind of æther (this obſervation is ſurely important in practice) by adding to ſtrong vinegar a little vitriolic, nitrous, muriatic, or fluor acid. Acetous æther is more eaſy of decompoſition than any other. No æther could be procured with phoſphoric acid, nor any with ſalt of benzoin alone, though the latter yields ſome with the help of muriatic acid. Neither did his trials ſucceed with acid of tartar, of lemons, of borax, of amber, and ſeveral compound ſalts.

CONCERNING the theory, he obſerves, that though it may ſeem, that ſome ſubſtance, which has an attraction for the phlogiſton of ſpirit of wine muſt be brought into action; yet this ſuppoſition can ſcarce be applied to the acetous æther, or that of benzoin, or to the acids of fluor and ſea-ſalt. But granting that theſe ſubſtances actually do attract phlogiſton, how is the *oil of ſpirit of wine* itſelf, or the æther, ſeparated from the water with which it was before united? Perhaps this phænomenon may be explained in the ſame way as the ſeparation of ſulphur from hepatic air: this latter is ſoluble like ſpirit of wine in water, and conſiſts of phlogiſton, ſulphur, and the principle of heat. On the acceſſion of a body that ſeparates the phlogiſton of this air, the principle of heat eſcapes, and the ſulphur is precipitated. In applying this ſuppoſition, Mr Scheele obſerves, that manganeſe has a ſtrong attraction for the inflammable principle when an acid acts upon it. This metallic calx, ſpirit of wine, and vitriolic or muriatic acid being added together, the former attracts part of its inflammable principle from the ſpirit, whence the heat (which is ſo conſiderable, that this mixture boiled of itſelf) eſcapes, and the ſubtile oil or the æther is ſeparated from the water. The portion of acid in highly-rectified æther, is very inſignificant, though it can be made obvious. The ſmall quantity of acetous and aerial acid, which he has obſerved in ſome diſtillations, proceeds from the decompoſition of a ſmall portion of æther; for it is very probable, that the oil of ſpirit of wine conſiſts of acetous acid and the principle of inflammability.

P. 318. Siderite.] THIS ſuppoſed new metal, ſiderite, [*Hydroſyrum, Waſſereiſein*] has been reduced by the firſt diſcoverer, Mr Meyer of Stettin, to a mere compoſition of iron and phoſphoric acid. The reader will be beſt pleaſed with his own reflections on the ſubject. "It is, ſays he, (Crell's Chemiſche Anna-
"len, B. i. St. 3.) but too eaſy to fall into miſtakes
"in chemiſtry; a truth daily confirmed by the num-
"ber of diſputed and contradictory experiments, and,
"of which, I myſelf probably furniſh a freſh ex-
"ample. For my new metal, obtained from caſt i-
"ron, that was run from a marſhy ore, of which I
"have treated in the obſervations of the Berlin So-

" ciety * is, in all probability, neither more nor leſs " than iron combined with phoſphoric acid. My rea- " ſons for this opinion are the following. I diſſolved " ſome of my ſuppoſed new metal in vitriolic acid, " taking care to uſe more acid than was neceſſary for " the ſolution. I obtained in the retort a gray " powder, and ſome ſulphur appeared on its neck. " Upon diſſolving the gray powder, and evaporating " the ſolution, I obtained a thick brown lixivium, " in which, when it had ſtood ſtill for a conſiderable " time, ſome cryſtals of true martial vitriol ſhot: " The remainder of the ley ſhewed the ſame phæ- " nomena, as thoſe I have noticed in the above men- " tioned papers. Hence it was too apparent, that " this metallic ſubſtance contained a large quantity of " iron. But with what could it be combined? I " could think of nothing but phoſphoric acid.

" HAVING poured a little water upon 20 grains of " iron that had been fluxed with inflammable matter, " and afterwards forged, I dropped into it a little phoſ- " phoric acid, procured by the burning of phoſphorus, " and applied heat. The acid attacked the iron, and " what was diſſolved formed a gray powder. I ad- " ded, by degrees, acid enough to diſſolve all the i- " ron, and then left it to dry by ſpontaneous evapo- " ration. The gray powder, when dry, weighed " 55½ grains. Upon trying to fuſe half a drachm of " this with 20 grains of glaſs of borax, I found that " it

---

* B. ii. p. 334.; and B. iii. p. 380.

“ it did not flow well: nor when 20 grains more
“ were added, did it run into complete fuſion. I
“ found in the glaſs particles of metal that were melt-
“ ed into grains not perfectly round, which were al-
“ ſo found to be very brittle, fuſed with difficulty
“ under the blow-pipe, and were converted into
“ ſcoriæ. The magnet had but little effect on them,
“ attracting only ſome ſmall particles. Upon the re-
“ maining earth I poured oil of vitriol, diluted with
“ an equal quantity of water; it was left to dry, and
“ then diſſolved in a very ſmall quantity of water,
“ and filtered it. Upon mixing this ſolution with wa-
“ ter, it became milk-white, and there fell down a
“ conſiderable quantity of white earth, in appear-
“ ance like the earth of ſiderite. I have not yet
“ been able to repeat and continue theſe experi-
“ ments; but have no doubt of their being confirm-
“ ed; and, in that caſe, I muſt alter the title of my
“ eſſays; but I hope the eſſays are not without their
“ uſe. What a plentiful ſource of phoſphoric acid
“ would be opened to us, if it were but eaſy to ſe-
“ parate? The cloſe combination of this acid with
“ iron, would alſo be remarkable.

“ Bergman has adopted my water-iron (Waſſer-
“ eiſen) as a new metal, under the title of ſiderum.”

What Mr Meyer gathers from theſe two experiments, is confirmed by Aſſeſſor Klaproth of Berlin, who, by a remarkable coincidence, came to the very ſame concluſion, without any communication with Mr

Meyer. He did not attempt to eſtabliſh his opinion by analytical experiments, as he conceived that it would be difficult to ſeparate the iron and acid, either by phlogiſton or any other way. He found, however, the artificial compound of phoſphoric acid and iron, to agree in its properties with the *calx ſideri alba* obtained by Bergman, and Meyer from cold-ſhort iron. Native Pruſſian blue contains this combination in much larger proportion.

* * * * *

SINCE the firſt publication of this diſſertation in 1775, beſides many alterations which totally change the diſpoſition of it, not leſs than nine new columns have been added, which, if all the rectangles were filled up, make 9×50=450 new rectangles. I have no doubt but that an equal or a greater number of additions will hereafter be made in an equal number of years. Even ſince the publication of the third volumn of the *Opuſcula* in 1783, two, or perhaps three ſubſtances have been diſcovered which will claim a place on the table of elective attractions; theſe are what Mr Scheele conſiders as the acid inherent in tungſtein, or *lapis ponderoſus*, the metal which Meſſrs Luyart obtained from tungſtein; for Wolfram only differs from it in being combined with iron and mangeneſe, and the acid of the ſilk-worm, and ſome other inſects, deſcribed by Mr Chauſſier in the Dijon Memoires for 1783. Little, I preſume, is as yet known concerning the elective attractions of theſe ſubſtances. Mr Scheele tells us, that the tungſtein acid, as he ſuppoſes it to be, when combined with volatile alkali, decompoſes nitrated lime, by a double elective attraction, and regenerates tungſtein. He adds, that it produces no change on ſolutions of alum or vitriolated lime, but it decompoſes acetated ponderous earth, the precipitate being quite inſoluble in water; that vitriolated iron, zinc, and copper, nitrated lead, ſilver, and mercury, with acetated lead, are precipitated white, and muriated tin-blue; and that corroſive ſublimate is not changed. All this was well known to Bergman; yet he has made no uſe of it, perhaps wiſely judging that the experiments of Mr Scheele, as well as his own, could not be much relied upon, on account of the ſmall quantity of matter they had to work upon: And, in fact, Meſſrs Luyart found, that what the Swediſh chemiſts had taken for the acid of tungſtein, was a triple ſalt, containing, beſides the ſubſtance furniſhed by the ſtone, ſome of the acid and alkali employed in extracting and ſaturating it.

* * * * *

SINCE the notes on p. 96. *note*, and ſome other paſſages, were printed, I have had the ſatisfaction of ſeeing a paper lately read by Mr Cavendiſh before the Royal Society, and containing experiments which deeply affect ſome of the general theories mentioned as well in the diſſertation as the notes. This paper, joined to that which I have ſo frequently quoted, tends to clear up more obſcurities in this branch of chemiſtry, than all the other facts and theories with which I am acquainted put together; and with whatever modeſty and ſimplicity his experiments may be related by the author, they ought to be accepted by thoſe who have been perplexed by the endleſs doubts and difficulties that occur in all that has been written on aeriform ſubſtances, as great and important diſcoveries.

I HAVE already mentioned (p. 326.) the idea, that Mr Cavendiſh had thrown out on the nature of phlogiſticated air, and obſerved, what was very obvious from the conſideration of that philoſopher's experiments, that the matter might be fully aſcertained, by treating this elaſtic fluid with vital air. Mr Cavendiſh did not fail to purſue the path which thus lay open before him. He mixed phlogiſticated and vital air together, and paſſed the electric ſpark through the mixture. In theſe trials, a diminution of bulk always was obſerved, inſomuch that when five parts of vital air were added to three of common air, almoſt the whole diſappeared. Moreover, by continuing his experiments, he diſcovered, that an acid liquor was produced, and that this acid was the nitrous. Thus, was his conjecture concerning the conſtitution of phlogiſticated air fully confirmed; and as, in the experiments already publiſhed, he had ſhown, that vital air is the ſame thing as water deprived of phlogiſton; ſo, in the preſent caſe, the addition of vital air is equivalent to the addition of water.

But his paper contains other experiments on the ſubject of aerial acid, that are equally intereſting. Mr Kirwan, ſo far from admitting the validity of Mr Cavendiſh's objections to theſe experiments in which the elaſtic ſpark is made to paſs through common or vital air, confined by a ſolution of litmus or of lime, retains them as the beſt arguments in favour of that opinion which he has eſpouſed. It was therefore deſirable to ſee how far experiment would countenance them.

When the electric ſpark was taken in ſmall portions of common air, confined by a ſolution of litmus, the liquor was turned red. This had been obſerved before; but it was not before known, that, by continuing the ſparks, the ſolution becomes quite clear and tranſparent; ſo, however, it is: beſides, half the air diſappears, and, by the addition of lime-water, it is reduced $\frac{1}{5}$ more. It is, therefore, unqueſtionably true, that the litmus ſuffers a decompoſition, loſes its purple colour, and yields fixed air; but there is nothing in any of theſe, or of the following experiments, which favours the opinion of air being diminiſhed by means of phlogiſton communicated by means of the electric ſpark.

When lime-water was uſed inſtead of litmus, not the leaſt cloud was obſerved; the air was reduced to $\frac{2}{3}$ of its original bulk; whereas, by phlogiſtication *,

it

---

* To ſhew the impropriety of the former erroneous phraſeology, is always among the firſt conſequences of new diſcoveries; for, as the expreſſion depends on the opinion that is formed of phænome-

na,

it loſes but $\frac{1}{8}$. When the ſpark was taken in common or vital air not quite pure, no cloud was perceived, nor even when ſome aerial acid was introduced; but when, beſides aerial acid, pure volatile alkali was added, a brown ſediment immediately appeared. Hence, it is evident, as Mr Cavendiſh obſerves, that the calcareous earth muſt have been ſaturated by ſome acid, (*viz.* the nitrous), which was generated during the experiment; but, on the addition of pure volatile alkali, four powers came into action, the nitrous acid uniting with the volatile alkali, and the aerial acid with the lime. The brown colour of the ſediment might be owing to ſome quickſilver being diſſolved. It is, moreover, undeniable, that, if any aerial acid had been generated, it would have precipitated ſome of the earth, till a ſufficient quantity of the other acid was produced to diſſolve the whole.

THUS then it appears, that what in the opinion of its warmeſt maintainer are the moſt convincing proofs of the doctrine in queſtion, are no proofs at all in its favour.

---

na, the former way of ſpeaking will ſcarce ever be adapted to the new notions. By altering the meaning of the preſent phraſe, it may perhaps be retained, ſince the vital part of the air does actually receive phlogiſton; but it ſeems to me to expreſs better, that the remaining elaſtic fluid has received an addition of phlogiſton, by which its nature has been changed: whence, there will ariſe this inconvenience, that paſt writers will have uſed the ſame expreſſion with one meaning, and future writers will uſe it with another. I think, therefore, that confuſion will be beſt avoided, by ſubſtituting a new one.

favour. I never experienced greater ſurpriſe than on reading theſe experiments of Mr Cavendiſh. The precipitation of lime, in theſe circumſtances, was ſo generally believed, that no one had ſcrupled to aſſume it as a certain ground of reaſoning. Speculative men cannot learn, from a more ſtriking inſtance, how neceſſary it is to begin with a ſtrict examination of facts.

BUT whence ariſes the aerial acid that appears in thoſe phlogiſtic proceſſes in which animals are concerned? We find it not only in the air that has been reſpired by animals provided with lungs, but Mr Scheele detected it in air in which he had kept inſects, and Mr Achard in common and vital air that had been injected into the cellular tiſſue of animals. If it does not proceed from any change of vital air, what remains but that it muſt be thrown off in ſubſtance? I would, therefore, propoſe this as a proper ſubject of experiment, not becauſe I think it calculated to decide the chemical queſtion concerning the conſtitution of the aerial acid, but becauſe it is a curious phyſiological problem. I know but one fact that has any immediate connection with the ſolution of this problem, and that is contained in Mr Achard's paper on artificial emphyſemas. He always found a large portion of aerial acid in inflammable air that had been forced into the cellular tiſſue of animals. If it was not contained beforehand in the inflammable air, and little or no common air was introduced along with it, which I think altogether unlikely, the reſult ſeems very much to favour the opinion that ſuppoſes aerial acid to be an animal emanation.

I KNOW not whether I ſhall eſcape cenſure for dwelling ſo long, both here and before, on the queſtion concerning the aerial acid; but I preſume, with ſome confidence, that no one who is capable of perceiving its extenſive influence on the theory of ſo many chemical operations, will blame me with much ſeverity. That the author of the diſſertation conſidered it as a queſtion of the utmoſt importance, appears from his accurate ſtatement of the ſeveral theories, and of the objections that may be made to them. *Gaudemus interea*, ſays he, *quæſtionem eo redactam fuiſſe, ut certitudo diu deſiderari nequit;* and accordingly, I think, we can now determine, with tolerable certainty, the merit of thoſe theories, as well as explain the nature of phlogiſtic proceſſes.

ON this ſubject, I have only to add, that in column 36. *vital air* ought to be placed above *nitrous acid*.

P. 188.] I FORGOT to obſerve, that ponderous earth had now been found, in more places than one, combined with aerial acid. The author himſelf received, a little while before his death, a ſpecimen of this combination, which was tranſmitted to him from this country.

EXPLANATION OF THE TABLE OF DOUBLE ELECTIVE ATTRACTIONS.

The firſt Forty take place in the HUMID WAY.

SCHEME 1. repreſents the decompoſition of vitriolated vegetable alkali by ponderous earth, the vitriolated ponderous earth falling down inſoluble, and the pure alkali remaining in the water.

SCHEME 2. ſhews that lime produces no ſuch effect.

SCHEME 3. the decompoſition of muriated foſſil alkali or ſea-ſalt by pure vegetable alkali, the new compound and the diſengaged alkali both remaining in the liquor.

SCHEME 4. the decompoſition of muriated lime (fixed ammoniac) by pure foſſil alkali, the lime falling to the bottom.

SCHEME 5. Lime produces no change in a ſolution of muriated fixed alkali.

SCHEME 6. the decompoſition of vitriolated magneſia (Epſom ſalt) by pure fixed alkali, the pure magneſia falling to the bottom, and the new compound being diſſolved.

Scheme 7. the decompoſition of corroſive ſublimate by pure vegetable alkali, the mercurial calx falling down, and the new compound (digeſtive ſalt) being diſſolved.

Scheme 8. the decompoſition of vitriolated iron (green vitriol) by lime, both the metallic calx and the new compound (gypſum) being precipitated.

Schemes 9. 10. 11. Theſe ſchemes are admirably explained in the ninth ſection; ſee alſo p. 170. The ninth repreſents the partial decompoſition of vitriolated vegetable alkali by the nitrous acid: the tenth and eleventh that of nitre and digeſtive ſalt by the acid of tartar.

N. B. There is an error in the tenth Scheme of the original plate, which, as well as many others, is corrected in the Tables annexed to this Tranſlation.

Scheme 12. ſhews, that, on the contrary, the acid of tartar does not, in any reſpect, change muriated foſſil alkali (ſea-ſalt).

Scheme 13. the decompoſition of borax by nitrous acid, the new compound being diſſolved, and the acid of borax appearing in a ſolid form.

Scheme 14. the decompoſition of vitriolated lime (gypſum) by acid of ſugar, the ſaccharated lime falling down inſoluble.

Scheme 15. ſhews the decompoſition of vitriolated magneſia by fluor acid: but ſee p. 187.

Scheme 16. ſhews the decompoſition of nitrated lime by vitriolic acid, the gypſum falling down.

Scheme 17. ſhews the decompoſition of white arſenic by dephlogiſticated marine acid, the acid of arſenic appearing in a ſolid form.

Scheme 18. ſhews that zinc precipitates ſilver from volatile alkali.

Scheme 19. ſhews, that ſaline liver of ſulphur is decompoſed by the acetous acid, the ſulphur being precipitated.

N. B. This Scheme includes many others, *a fortiori*.

Scheme 20. ſhews the decompoſition of calcareous liver of ſulphur by vitriolic acid, both gypſum and ſulphur falling down.

Scheme 21. ſhews, that when ſolutions of vitriolated vegetable alkali and muriated lime are mixed, a double decompoſition takes place, the digeſtive ſalt being diſſolved, and the gypſum precipitated.

Scheme 22. ſhews, that when vitriolated vegetable alkali in ſolution is added to muriated lead (plumbum corneum), a double decompoſition takes place, the ſea-ſalt being diſſolved, and the vitriolated lead precipitated.

Scheme 23. ſhews, that when muriated vegetable alkali and vitriolated lime are mixed together, no double decompoſition takes place.

Scheme 24. ſhews, that when vitriolated volatile alkali and muriated mercury are added together, a double decompoſition takes place, the muriated volatile alkali (ſal ammoniac) being diſſolved, and the vitriolated mercury precipitated.

Scheme 25. ſhews, that when nitrated terra ponderoſa and oxalited volatile alkali are added together, an exchange of principles takes place, the oxalited earth falling down, and the nitrous ammoniac being diſſolved.

Scheme 26. ſhews the double decompoſition of nitrated ſilver and common ſalt, the new neutral ſalt (nitrated foſſil alkali) being diſſolved, and the muriated ſilver (argentum corneum) falling down.

Scheme 27. ſhews, that when tartar and nitrated mercury are mixed, they ſuffer a mutual decompoſition,

tion, the nitre being diſſolved, and the tartarized mercury precipitated.

SCHEME 28. ſhews, that when borax and nitrated mercury are mixed, a double decompoſition takes place, the borakated mercury falling down, and the nitrated foſſil alkali diſſolved.

SCHEME 29. ſhews, that when muriated magneſia and acetated ſilver are mixed, an exchange of principles takes place, the acetated magneſia being diſſolved, and the muriated ſilver precipitated.

SCHEME 30. ſhews, that when vitriolated ſilver and muriated lead are mixed, a double exchange happens, and both muriated ſilver and vitriolated lead fall down inſoluble.

SCHEME 31. ſhews, that when nitrated ſilver and muriated copper are mixed together, a double decompoſition takes place, the nitrated copper being diſſolved, and the muriated ſilver falling down.

SCHEME 32. ſhews, that when common ſalt and aerated vegetable alkali are mixed, a double exchange takes place, the digeſtive ſalt (muriated vegetable alkali) and the aerated foſſil alkali being both diſſolved.

Scheme 33. ſhews, that when corroſive ſublimate and aerated vegetable alkali are mixed, a double decompoſition happens, the muriated vegetable alkali being diſſolved, and the aerated mercury precipitated.

Scheme 34. ſhews, that when nitrated lead and aerated foſſil alkali are mixed, a double exchange is effected, the aerated lead falling down, and the nitrated foſſil alkali being diſſolved.

Scheme 35. ſhews, that when vitriolated magneſia and aerated fixed alkali are mixed together, a double exchange takes place, the vitriolated alkali being diſſolved, and the aerated magneſia falling down.

Scheme 36. ſhews, that when muriated lime and aerated volatile alkali are mixed together, a double exchange takes place, the muriated volatile alkali (ſal ammoniac) being diſſolved, and the aerated lime falling down.

Scheme 37. ſhews, that when aerated volatile alkali is added to a tincture of pure vegetable alkali, the vegetable alkali combines with the aerial acid, and falls down, while the volatile alkali combines with the alcohol.

Scheme 38. ſhews, that when to nitrated ſilver copper is added, a double exchange takes place, the phlogiſton of the copper unites with the ſilver, which falls down, and the nitrous acid with the copper, which is diſſolved.

Scheme 39. ſhews, that if iron be added to copper diſſolved in vitriolic acid, the phlogiſton combines with the calx of copper, which is precipitated, and the vitriolic acid with the calx of iron, which is diſſolved.

Scheme 40. ſhews, that when ſaline liver of ſulphur is mixed with acetated lead, a double exchange takes place, the lead falling down with the ſulphur, and the acetated alkali being diſſolved.

N. B. I cannot undertake to aſſign the reaſon why thoſe caſes of double attraction which are effected by the tinging acid, in combination with alkalis, and, as I ſuppoſe, with abſorbent earths, at leaſt with lime, are omitted in the preſent Table. The nature of the operation could not be unknown to the author, becauſe he mentions it expreſsly, p. 302. I ſee, indeed, that he has omitted others that were known to him; nay, that he mentions in this very diſſertation; whether it was that the reader could eaſily infer them from thoſe caſes that are repreſented in the Schemes, or whether they were doubtful, or of ſmall importance in practice: but none of theſe conſiderations apply to the attractions in queſtion; for they ſeem to be well aſcertained as to their theory, and are undoubtedly of daily occurrence in the practice of chemiſtry.

It remains, that the deficiency be, in ſome meaſure, ſupplied; and I cannot do this better than by the following table, which I have extracted from the author's eſſay on metallic precipitates. The firſt column ſhews the colour of the precipitate; the ſecond its quantity, from 100 grains of the regulus, diſſolved in ſome acid menſtruum.

	Colour.	Weight.
Gold,	yellow,	not perfectly precipitated.
Platina,		no precipitation.
Silver,	dark yellow,	145.
Mercury,	whitiſh at firſt; turns yellow when dry,	apt to be rediſſolved.
Lead,	white.	
Copper,	greeniſh yellow; blackiſh red when dry,	530.
Iron,	deep blue,	590.
Tin,	white,	250.
Biſmuth,	yellowiſh,	180.
Nickle,	yellow; dark brown when dry,	250.
Arſenic,	white,	180.
Cobalt,	bluiſh red; browniſh red when dry,	142.
Zinc,	white; citron yellow when dry,	495.
Antimony,	white,	138.
Manganeſe,	at firſt bluiſh, then yellowiſh blue, laſtly dark green.	

THE precipitates of tin, biſmuth, nickle, antimony, and manganeſe, generally have their colours altered by the admixture of particles of Pruſſian blue, from the iron that is preſent. The ponderous earth is likewiſe precipitated by the combination of the tinging acid and alkali, (Preface to the Sciagraphia, and Withering, *ibid.*). Hence I imagined, that vitriolated ponderous earth might poſſibly be decompounded by the ſame powers. Having reduced a ſmall quantity to a fine powder, I digeſted it in the ſunſhine for ſeveral hours in a ſolution of Pruſſian alkali, prepared according to Mr Scheele's method. After the ſupernatant liquor was poured off, and the reſiduum edulcorated, nitrous acid was added to it, which I ſuppoſed would expel the tinging acid from the earth, if any ſuch union had taken place, and diſſolve the latter; but upon dropping ſome vitriolic acid into the nitrous, no precipitation was obſervable, which ſhews that it held no ponderous earth in ſolution. Whether this decompoſition may be accompliſhed by applying a ſtronger heat, or following other methods, I know not.

THIS experiment led me to doubt, whether the Pruſſian alkali was capable of decompounding certain other compounds of acids and metals, beſides the ſolution of platina. If any would reſiſt its action, I thought vitriolated and muriated lead, and perhaps ſilver, to be the moſt likely; particularly the former, from the conjecture that Bergman has thrown out in the preface to his *Sciagraphia*, concerning the identity of the calx of lead and ponderous earth. I was, moreover, unable to recollect any thing ſatisfactory on this point in authors. Bergman himſelf, (Opuſc. Diſſ. xxiii. § 5. letter E), ſays only, that “ lead is “ precipitated of a white colour from its ſolution in “ nitrous acid by aerated and cauſtic foſſil alkali, as “ well as by Pruſſian alkali.” I attempted, therefore, to ſatisfy myſelf, by repeating the foregoing experiment with vitriolated lead, except that I happened to uſe the acetous acid inſtead of the nitrous. But I now obſerved a white precipitate, both on the addition of vitriolic and muriatic acid, which ſeems to ſhow, that a double decompoſition had actually taken place. However, farther enquiry is neceſſary before any thing certain is determined; and I purpoſe to examine the ſeveral metallic ſalts above mentioned, when I have ſome tolerable convenience for making chemical experiments.

SCHEME 41. If vitriolated vegetable alkali be diſtilled with phoſphoric acid, it will be decompounded; the vitriolic acid will be driven over, and the phoſphorated alkali will remain at the bottom.

SCHEME 42. If common ſalt be ſubjected to diſtillation with nitrous acid, the marine acid will riſe, and the nitrated foſſil alkali remain in the retort.

Scheme 43. If common ſalt be ſubjected to diſtillation with acid of arſenic, the marine acid will riſe, and the arſenicated foſſil alkali remain in the retort.

Scheme 44. If muriated volatile alkali (ſal ammoniac) be diſtilled with vitriolic acid, the marine acid will riſe, and the vitriolated volatile alkali will likewiſe be ſublimed.

Scheme 45. If marine acid be diſtilled with the black calx of mangane{ſ}e, it will be dephlogiſticated and riſe, the white calx remaining fixed.

Scheme 46. If ſal ammoniac be treated with quicklime in diſtilling veſſels, the pure volatile alkali will ariſe, and the muriated lime remain.

Scheme 47. If ſulphurated mercury (cinnabar) be ſubjected to diſtillation with iron, the mercury will riſe in its metallic form, and the ſulphurated iron remain.

Scheme 48. If arſenicated fixed alkali be ſublimed with inflammable matter, the arſenic will riſe in a reguline form, and the alkali will remain?

Scheme 49. If phoſphorated volatile alkali be ſublimed with inflammable matter, it will be decompoſed, and the volatile alkali and phoſphorus will both ariſe?

Scheme 50. ſhews, that muriated lime is not decompounded by being expoſed to diſtillation with volatile alkali.

Scheme 51. ſhews, that fluorated lime is not decompounded by being expoſed to fuſion in a crucible with fixed vegetable alkali.

Scheme 52. ſhews, that when an alloy of gold and ſilver is fuſed with ſulphur, the ſulphur combines with the ſilver, and leaves the gold free.

Scheme 53. ſhews, that when ſulphurated lead and iron are fuſed together, the ſulphur unites with the iron, and leaves the lead free.

Scheme 54. ſhews, that when copper is fuſed with a combination of ſaline liver of ſulphur and ſilver, the copper unites with the liver of ſulphur, and the ſilver is ſeparated.

Scheme 55. ſhews, that when nitre and muriatic acid are diſtilled together, the nitrous acid attracts the phlogiſton of the marine acid, and quits the vegetable alkali.

Scheme 56. ſhews, that when nitre and white arſenic are diſtilled together, the nitrous acid attracts the phlogiſton, and riſes, while the arſenical acid combines with the vegetable alkali.

Scheme 57. ſhews, that when common ſalt and white arſenic are ſubjected to diſtillation together, no change is effected.

Scheme 58. ſhews, that when corroſive ſublimate is ſubjected to diſtillation with regulus of antimony, the calx of the mercury unites with the phlogiſton of the antimony, and riſes, while the muriatic acid combines with the calx of antimony, and riſes in like manner.

Scheme 59. ſhews, that when vitriolated vegetable alkali is expoſed to ſublimation with arſenicated volatile alkali, the vitriolic acid combines with the volatile alkali, and riſes, while the arſenical acid combines with the vegetable alkali, and remains fixed.

Scheme 60. ſhews, that when nitrated vegetable alkali and vitriolated volatile alkali are expoſed to ſublimation, the nitrous acid riſes, combined with the volatile alkali, while the vitriolated vegetable alkali remains fixed.

Scheme 61. ſhews, that when muriated foſſil alkali and vitriolated mercury are ſublimed together, the muriatic acid combines with the mercury, and riſes, while the vitriolated foſſil alkali remains at the bottom.

Scheme 62. ſhews, that when muriated volatile alkali and aerated lime are expoſed to ſublimation together, the aerial acid and volatile alkali riſe combined, while the muriated lime remains fixed.

Scheme 63. ſhews, that when aerated vegetable alkali and fluorated lime are fuſed together, the acid of fluor combines with the vegetable alkali, and the aerial acid with the lime, both remaining fixed.

Scheme 64. ſhews, that when an alloy of gold and copper is fuſed with ſulphurated antimony, the ſulphur unites with the copper, and the gold with the antimony, both remaining fixed.

MVSEVM
BRITAN
NICVM

EMEN

EMENDANDA.

P. 41. l. 16. add *vitriolated tartar, nitre, and ſome other ſalts, are thus thrown down.*

P. 66. l. the laſt, ſtrike out *or not.*

P. 68. l. 12. for *a* read *n.*

P. 107. l. 13. for *acids,* read *metals.*

P. 170. l. 5. after *manner,* inſert *the acids of.*

P. 182. l. 17. read the words, *which come next,* immediately after *ſea-ſalt.*

P. 236. l. 14. inſert : between the two laſt quantities of the equation.

P. 256. l. 17. after *ſpecific,* add *heats.*

N. B. There are a few *literal errors,* which the context will at once direct the reader how to correct: And if there be a few wrong ſtrokes yet remaining in TABLE III. they may be corrected from the correſponding Table of words.

Chemical S

Acids.

1. + ⦸ vitriolic
2. + ⦶🜍 — phlogisticated
3. + ⦶ nitrous
4. + ⦶🜍 — phlogisticated
5. + ⊖ marine
6. + ⊖🜄 — dephlogisticated
7. ∇R Aqua regia
8. + F of fluor
9. o+o arsenic
10. + ⌂ borax
11. + ⊗ sugar
12. + 🜿 tartar
13. + ⊕ sorrel
14. + C lemon
15. + o⚲o benzoin
16. + ↀ amber
17. + ⊽ sugar of milk
18. ⁜ acetous distilled
19. + ⊽ milk
20. + f ants
21. + 8 fat
22. + 🜍 of phosphorus
23. + 🜍 perlatum
24. + 🜍 of pruſsian blue
25. 🜁 aerial

Alka

26. ⊕√vp pure f
27. ⊕√mp pure f
28. ⊖^p pure v

Ear

29. ¥p pure p
30. ¥p pure c
31. ¥p pure m
32. ∀p pure ar
33. 🝗p pure si
34. ∇ water
35. 🜁 vital a
36. 🜍 phlogis
37. △ matter
38. 🜍 sulphu
39. ⊕🜍 saline
40. ∇̊ spirit
41. °8° Æther
42. °°° eſsentia
43. ⊙ unctuou

ical Signs explained.

Alkalis.

pure fixed vegetable
pure fixed mineral
pure volatile

Earths,

pure ponderous
pure calcareous, Lime
pure magnesia
pure argillaceous
pure siliceous

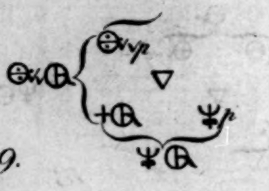
---

vater
ital air
hlogiston
atter of heat
ulphur
aline hepar
pirit of wine
ther
sential oil
nctuous oil

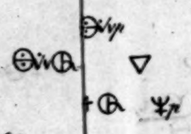
Metallic Calces.

44. Ψ☉ gold
45. Ψ☽☉ platina
46. Ψ☽ silver
47. Ψ☿ mercury
48. Ψ♄ lead
49. Ψ♀ copper
50. Ψ♂ iron
51. Ψ♃ tin
52. Ψ♉ bismuth
53. Ψ⚲ nickle
54. Ψ⚯ arsenic
55. Ψ☊ cobalt
56. ΨÔ zinc
57. Ψ♁ antimony
58. Ψ⦶ manganese
59. Ψ♂▼ siderite

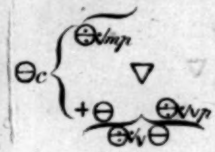
1.



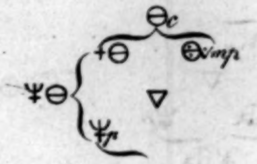
2.



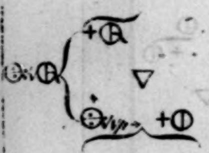
3.



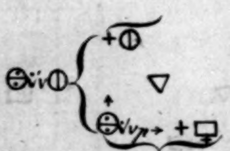
4.



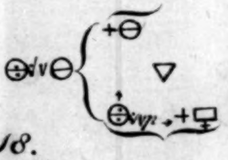
9.



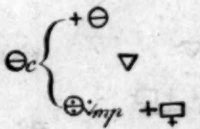
10.



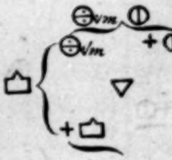
11.



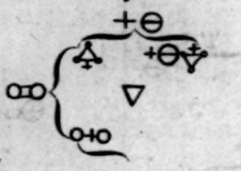
12.



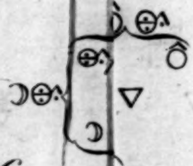
13.



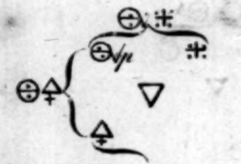
17.



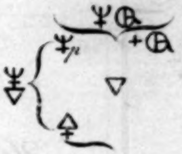
18.



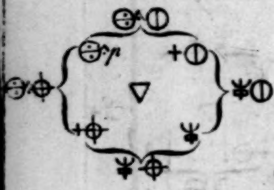
19.



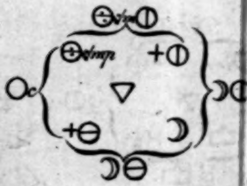
20.



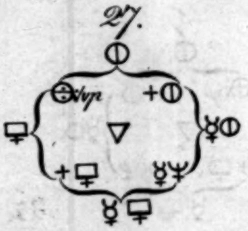
25.



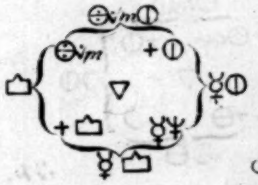
26.



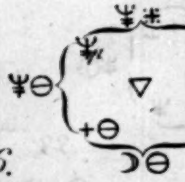
27.



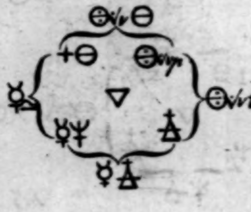
28.



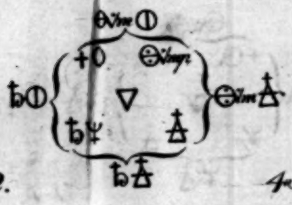
29.



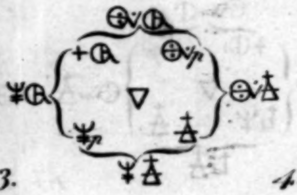
33.



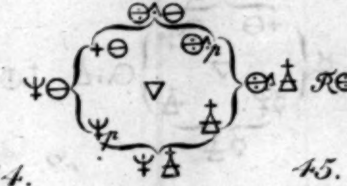
34.



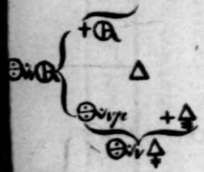
35.



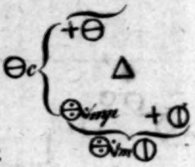
36.



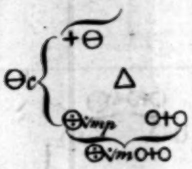
41.



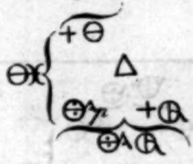
42.



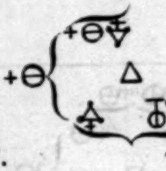
43.



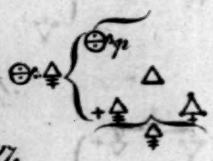
44.



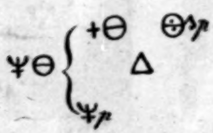
45.



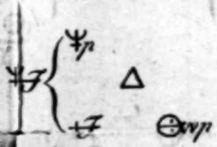
49.



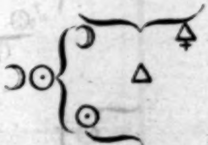
50.



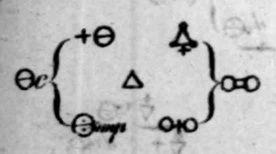
51.



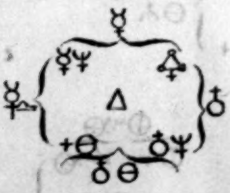
52.



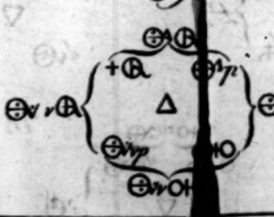
57.



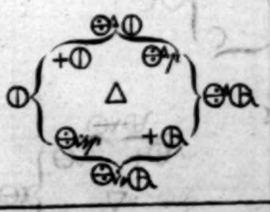
58.



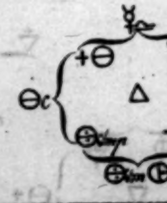
59.



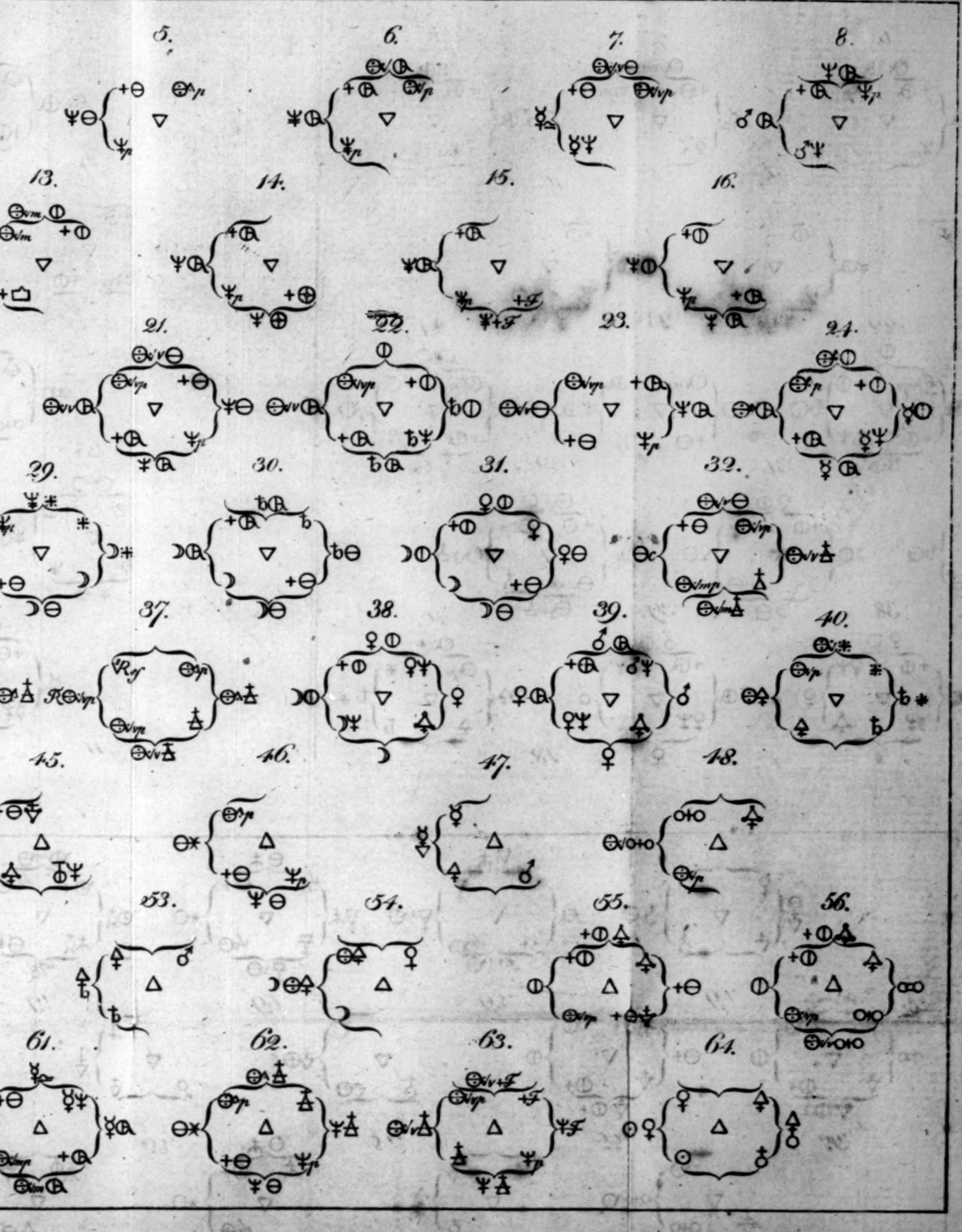
60.



61.



Tab. 1.


5.
6.
7.
8.
13.
14.
15.
16.
21.
22.
23.
24.
29.
30.
31.
32.
37.
38.
39.
40.
45.
46.
47.
48.
53.
54.
55.
56.
61.
62.
63.
64.

Single electiv

In the M

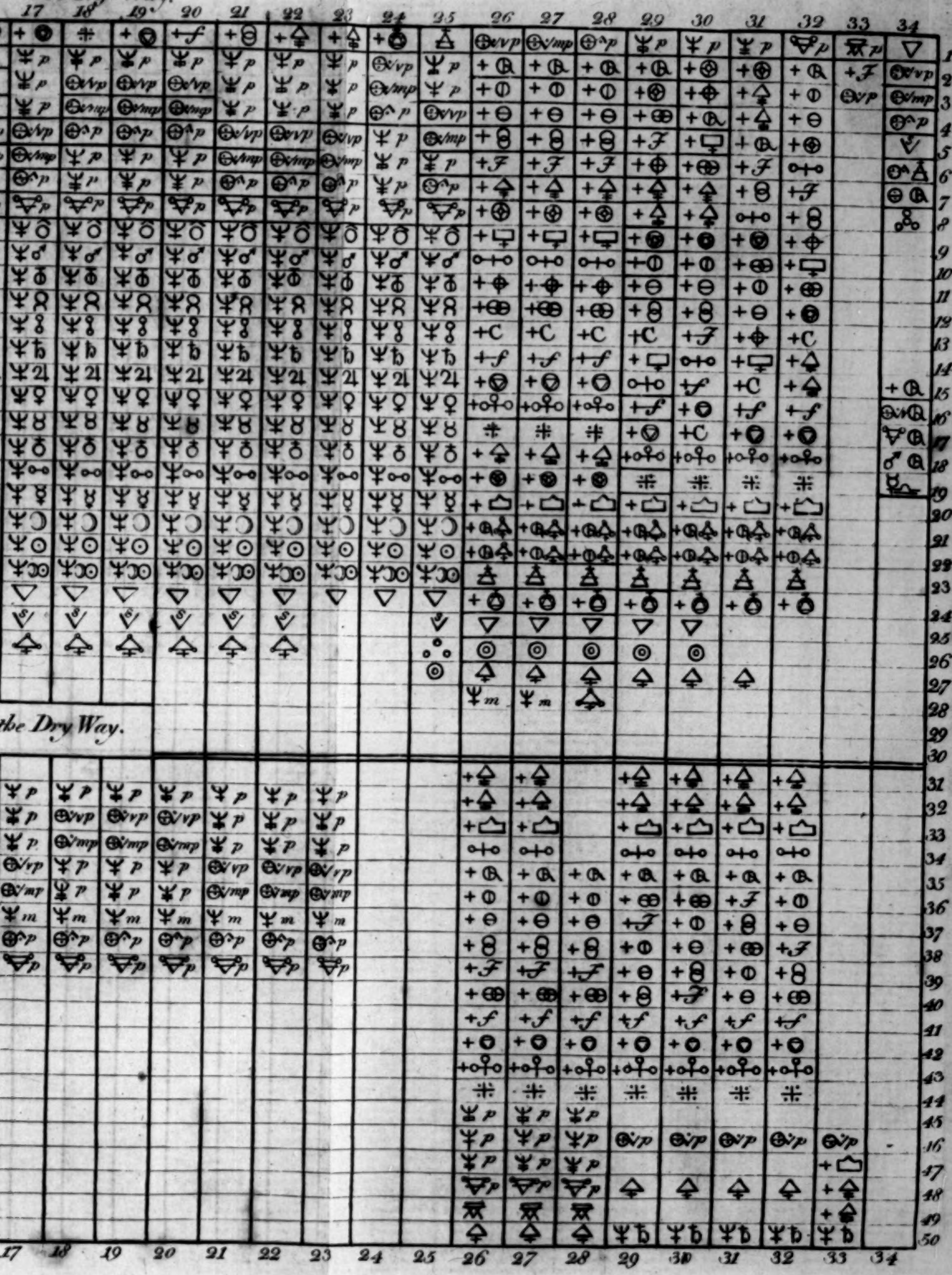
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	+⊕	+⊕🜍	+⦶	+⦶🜍	+⊖	+⊖▽	▽R	+F	o+o	+⌂	+◎	+♀	+⊕	+C	+o♀o	+⊞	+◉
2	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp
3	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp
4	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp
5	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	Ψp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp	⊕√vp
6	Ψp	Ψp	Ψp	Ψp	Ψp	Ψvp	Ψp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp	⊕√mp
7	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p	⊕^p
8	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p	▽p
9	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ	ΨÔ
10	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂	Ψ♂
11	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ	ΨΦ
12	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ	ΨȢ
13	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8	Ψ8
14	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄	Ψ♄
15	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃	Ψ♃
16	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀	Ψ♀
17	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉	Ψ♉
18	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁	Ψ♁
19	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o	Ψo-o
20	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿	Ψ☿
21	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽	Ψ☽
22	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉	Ψ☉
23	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉	Ψ☽☉
24	▽	▽	▽	▽	▽	▽	▽	▽	🜍	▽	▽	▽	▽	▽	▽	▽	▽
25	▽S	▽S	▽S	▽S	▽S	▽S	▽S	▽S	▽	▽S	▽S	▽S	▽S	▽S	▽S	▽S	▽S
26	🜍	🜍	🜍	🜍	🜍	🜍	🜍	⊼	▽S	🜍	🜍	🜍	🜍	🜍	🜍	🜍	🜍
27																	
28																	
29																	
30																	

In the Dry W

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
31	🜍		🜍		🜍		🜍		🜍								
32	Ψp		Ψp		Ψp		Ψp	Ψp	Ψp	Ψp					Ψp	Ψp	Ψp
33	⊕√vp		⊕√vp		⊕√vp		⊕√vp	Ψp	Ψp	Ψp					Ψp	Ψp	Ψp
34	⊕√mp		⊕√mp		⊕√mp		⊕√mp	Ψp	Ψp	Ψp					Ψp	Ψp	Ψp
35	Ψp		Ψp		Ψp		Ψp	⊕√vp	⊕√vp	⊕√vp					⊕√vp	⊕√vp	⊕√vp
36	Ψp		Ψp		Ψp		Ψp	⊕√mp	⊕√mp	⊕√mp					⊕√mp	⊕√mp	⊕√mp
37	Ψm		Ψm		Ψm		Ψm	Ψm	Ψm	Ψm					Ψm	Ψm	Ψm
38	⊕^p		⊕^p		⊕^p		⊕^p	⊕^p	⊕^p	⊕^p					⊕^p	⊕^p	⊕^p
39	▽p		▽p		▽p		▽p	▽p	▽p	▽p					▽p	▽p	▽p
40										⊼							
41																	
42																	
43																	
44																	
45																	
46																	
47																	
48																	
49																	
50																	
	1	2	3	4	5	6	7	8	9	10	11		13	14	15	16	17

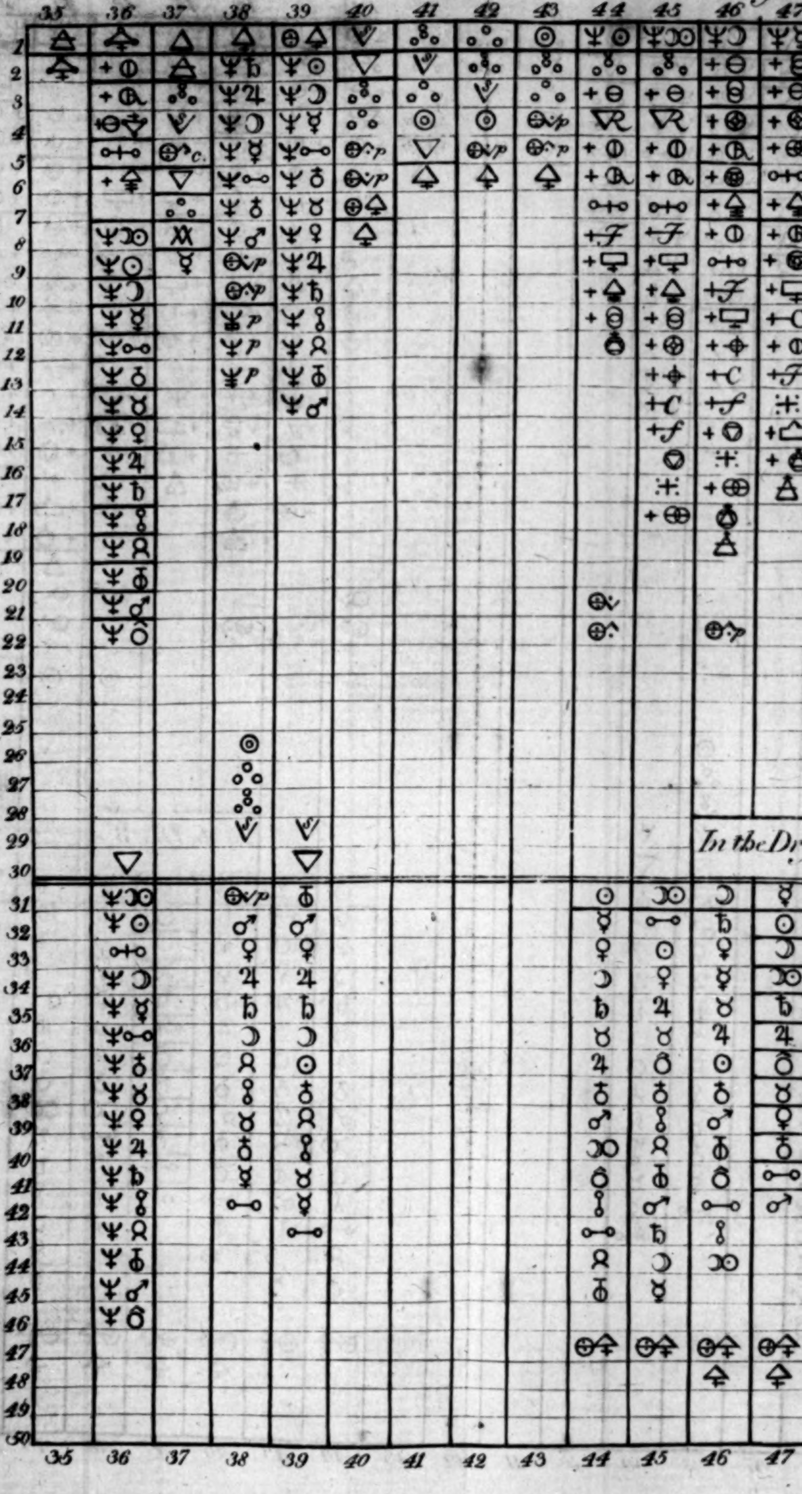
e elective Attractions. **Tab. II.**

In the Moist Way.


17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
the Dry Way.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50

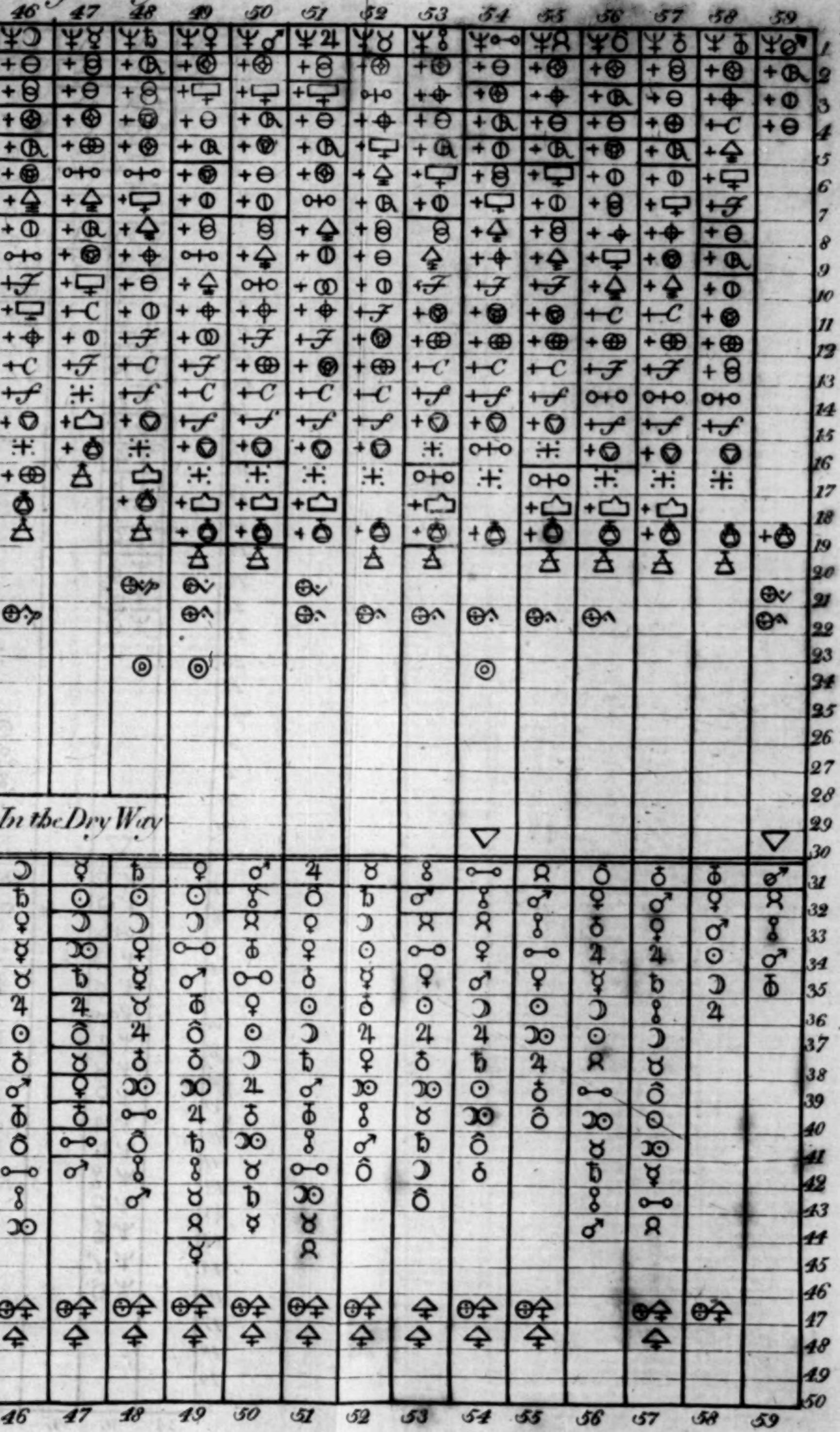
Single elective

In the Moist


35
36
37
38
39
40
41
42
43
44
45
46
47
In the Dr

ective Attractions. **Tab. III.**

Moiſt Way.


46
47
48
49
50
51
52
53
54
55
56
57
58
59
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
In the Dry Way
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
46
47
48
49
50
51
52
53
54
55
56
57
58
59